The
American Midland Naturalist

Founded by J. A. Nieuwland, C.S.C.

John D. Mizelle, Editor

CONTENTS

Vol. 39 March, 1948 No. 2

NOTE: THE AMERICAN MIDLAND NATURALIST, published by the University of Notre Dame, is primarily, though not exclusively, devoted to the Natural History of the Middle West. A wide selection of papers on botany, paleontology and zoology is published in bi-monthly issues, three of which make up a volume.

Authors are invited to submit carefully prepared manuscripts and requested to limit tables and illustrations as much as possible. Abstracts and reprint orders should accompany manuscripts or corrected proofs.

The following numbers are out of print: Vol. 1 (1, 4, 5, 8-12); Vol. 2 (1, 3, 8, 9); Vol. 3 (all numbers); Vol. 4 (1-9, 11, 12); Vol. 5 (1, 6, 8); Vol. 6 (4, 5, 7-12); Vol. 7 (1, 6-12); Vol. 8 (2); Vol. 11 (1); Vol. 12 (12); Vol. 14 (1, 5); Vol. 15 (4); Vol. 21 (3); Vol. 22 (1); Vol. 23 (all numbers); Vol. 24 (3); Vol. 25 (1, 2); Vol. 26 (2); Vol. 27 (1); Vol. 36 (1). Volume groups 1-12, 13-18 and 19-39 contain 12, 6 and 3 issues respectively. Available issues of Vols. 1-6 $4.00, single issues 40 cents; Vol. 7 $2.50, single issues 25 cents; Vols. 8-12 $4.00, single issues 40 cents; Vols. 13, 14 $2.50, single issues 50 cents; Vol. 15 $3.00, single issues 60 cents; Vol. 16 $4.00, single issues 75 cents; Vol. 17 $5.50, Part I, $2.50, Nos. 2-6 75 cents each; Vol. 18 $4.00, single issues 75 cents; Vols. 19-39 $3.00, single issues $1.25. Subscription price per year $6.00

Inquiries concerning exchanges for specimens, journals, special volumes or duplicate books should be addressed to *The American Midland Naturalist*, Notre Dame, Indiana where subscriptions and payments are also received. Offers should accompany requests for exchange.

Abbreviated citation: *Amer. Midl. Nat.*

The *American Midland Naturalist* is indexed in the INTERNATIONAL INDEX.

Entered as second-class matter at Notre Dame, Indiana. Acceptance for mailing at special rate of postage provided for in section 1103, Act of October 3, 1917, authorized on July 3, 1918.

The American Midland Naturalist

Published Bi-Monthly by The University of Notre Dame, Notre Dame, Indiana

Vol. 39 | MARCH, 1948 | No. 2

The Whales and Dolphins of Washington State
with a Key to the Cetaceans of the West Coast of North America

Victor B. Scheffer
Fish and Wildlife Service, U. S. D. I.
Seattle, Washington

John W. Slipp
Regional Museum and Aquarium, Point Defiance Park,
and Washington State Historical Society, Tacoma, Washington

CONTENTS

Figs. 1, 2.—1. Neah Bay natives capturing a whale; throwing the second harpoon. Note seal-skin float. (Asahel Curtis photo no. 56519); 2. Natives landing the carcass of a gray whale, buoyed by seal-skin floats, at Neah Bay about 1910-1912. (Asahel Curtis photo no. 19220).

Introduction

We offer in this report a check-list of the whales and dolphins of Washington waters, a description of the shore whaling industry which was once important here, and an assortment of notes on the anatomy and behavior of local cetaceans.

The environment.—For the student of marine mammals, the state of Washington offers many advantages. It lies in the overlapping ranges of subarctic as well as subtropical species and its fauna is thus fairly rich. It presents a variety of marine habitats offshore, along the coast, and in a maze of inland sounds and channels. The continental shelf, — that is, the coastal sea bottom at a depth of 100 fathoms or less — extends for a distance of 30 to 60 miles offshore, narrower at the southern end of the state and wider off the Strait of Juan de Fuca. Seaward of the continental shelf, the great current of the North Pacific Drift moves slowly southward the year around, while inshore the Davidson Current moves northward at a fairly rapid rate in the winter and remains stationary or moves slowly southward in the summer. The ocean waters are cold throughout the year. Monthly mean surface temperatures of waters on the continental shelf vary from 46.1° F. in February to 55.7° in August, with a yearly mean of 50.5° (U. S. Weather Bureau, 1938, charts 115-126). The inland waterways of the state are in places surprisingly deep. Thus, maximum depths of the channel at selected localities are (in fathoms): Neah Bay 165, Port Angeles 84, northern San Juan Islands 128, Seattle 142, Tacoma 99, and Steilacoom 102.

Source materials.—We have gathered information on the cetaceans of the state from many sources: specimens, photographs, published records, news items, and accounts of informants. We find it impossible to discuss the species in a uniform manner because, for certain ones, we have little more than a photograph or a fragment of a skull, while for others we have dozens of records and specimens.

History of Whaling in Washington

Aboriginal.—Heizer (1943) has described and classified the whaling methods of the aborigines around the north Pacific rim from Japan to the Washington coast. Whaling with *harpoon, line, and float* was employed by the Indians of the Olympic and Vancouver Island seacoasts, by the Eskimo and Chuckchee north and south of Bering Strait, and by the Koryak and Japanese farther south on the Asiatic coast. Whaling by *netting* (Japanese and Koryak) and by *poisoning* (Ainu, Kamchadal, Aleut, and Koniag) were also employed. The natives of the coast between the Gulf of Alaska and Vancouver Island were not whalers, and some even refused to eat the flesh of whales found stranded on the beach, possibly as a result of unhappy experiences with poisoned carcasses which had drifted down to them from the Aleut-Koniag region.

Waterman believed that it was "impossible to discover which of the various coast tribes originated the hunting of the whale. It is certain, however,

Fig. 3.—Natives at Neah Bay cutting a gray whale to be apportioned among the villagers, about 1910-1912. (Asahel Curtis photo no. 19253).

that it sprang up somewhere along the west coast of Vancouver Island. Probably the Nootka and Clayoquot had as much to do as anybody with developing the industry. The art is not found on the *east* coast of Vancouver Island, nor does it exist among the tribes of [southeastern] Alaska, as the Haida and Tlingit. Whaling is practiced by the Quilliute and Quinault, south of Cape Flattery, but the practice is unknown beyond their territory. Whales are spoken of in the accounts of the tribes living all along the coast of Oregon and Washington, and whale products of various sorts are utilized, as they are also in Alaska, but the tribes who actively pursue the big cetaceans are those in the vicinity of Cape Flattery and Vancouver Island. The Makah, who live near the southern frontier of the region where whaling is practiced, would hardly be looked upon (in the absence of positive proof) as the originators of the practice. All sources agree, however, that they long ago attained first rate skill at it." (1920, p. 47.)

The *scavenging* methods employed by the natives of southwest Washington are described in Swan's account of the salvaging of a humpback whale which drifted ashore on the Washington coast between Grays Harbor and Willapa Bay in late March, 1855 (1857, pp. 360-364).

The best accounts of whaling as practiced by Washington natives are given by Swan (1870, pp. 19-22) and Waterman (1920). Boas (1909), Curtis (1913), and Reagan (1909, 1925) have also treated the subject, with emphasis on whaling ceremonies. Briefly, the practice of the natives was to harpoon the whale from the bow of an 8-man dugout canoe, each containing a harpooner, 6 paddlers, and a helmsman. The barbed harpoon head was fastened to a 5-fathom lanyard of whale sinew, which in turn was fastened to one or more inflated seal-skin floats joined by lines made of various fibers. The course of a wounded whale was indicated by the floats, allowing the men to plant additional harpoons, each with its network of floats, until the animal was dead, when the floats served to prevent it from sinking. Butchering was carried out with great enthusiasm on the beach; the carcass was divided according to tradition, and was completely utilized (Figs. 1-3).

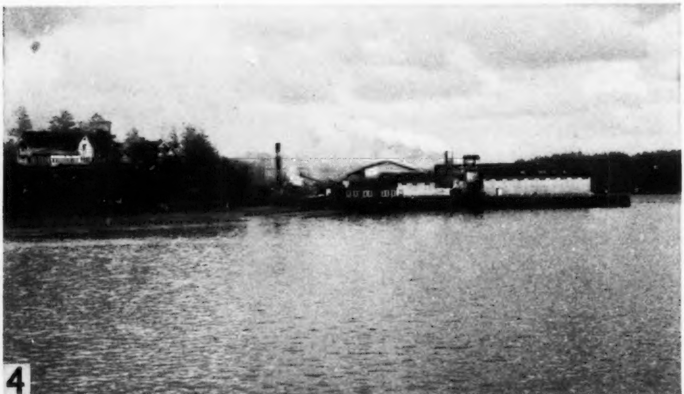
The Makah and Quillayute were familiar with about a dozen "kinds" of cetaceans, although it is difficult to determine, in most cases, whether a native name was applied to a single species, to a group of naturally related species (e.g., beaked whales), or to a group of unrelated species of like behavior in the water. According to informants Fred Irving and Lance Kalappa, the Makah name for whale is *che-tap-okh*. According to Morton Penn, the Quillayute name is *qua-ah-kluh*. Neither tribe has a term meaning "cetacean."

Commercial whaling.—Shore whaling on the Pacific coast of America was begun in 1851 at Monterey, California, and was carried on for 36 years at various points along the California and Lower California coasts. In 1887, the last station, at San Simeon, was abandoned because of the scarcity of gray whales and other inshore species that supported the shore whaling industry (Starks, 1922). Petroleum, gas, and electricity replaced whale oil as a fuel and an illuminant, and high grade whalebone from the Arctic right whales crowded local whalebone off the market. San Francisco grew as a port of

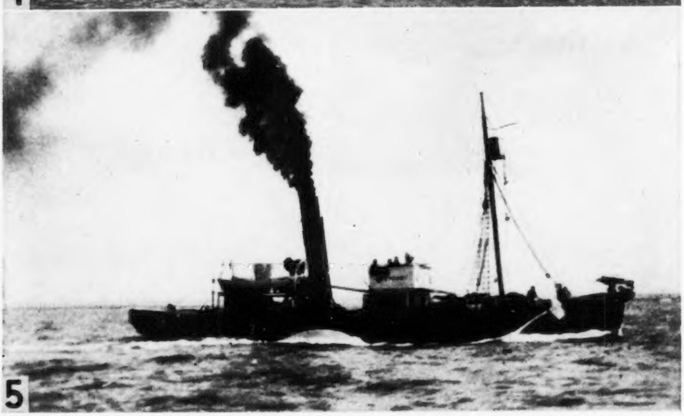
Fig. 3.—Natives at Neah Bay cutting a gray whale to be apportioned among the villagers, about 1910-1912. (Asahel Curtis photo no. 19253).

registry and a refinery center for the Arctic whaling vessels, but shore whaling was not to regain its importance until about 1905, when a market for soap and fertilizer developed and when the modern steam whaler equipped with cannon harpoon began to capture whales in a highly efficient manner.

Whaling on the high seas centered mainly on the Arctic, Bering, and Kodiak grounds (from Vancouver Island to 150° W. in the Aleutians) in summer and along the Lower California coast in winter. Whaling off the Washington coast in early days was done more or less incidentally by ships travelling between these extremes. Ships lowered for an occasional kill off-



4



5

Figs. 4, 5.—4. Shore station of the American Pacific Whaling Company at Bay City, sometime between 1911 and 1925. (Jones Photo Company, Aberdeen); 5. Killer ship WESTPORT towing a whale to the Bay City station, about 1912. (Photo from Effie Rankin).

shore, or entered the Strait of Juan de Fuca and other harbors along the coast. The record of C. M. Scammon (1874), a whaling master, gives the only important account of this era of whaling in Washington.

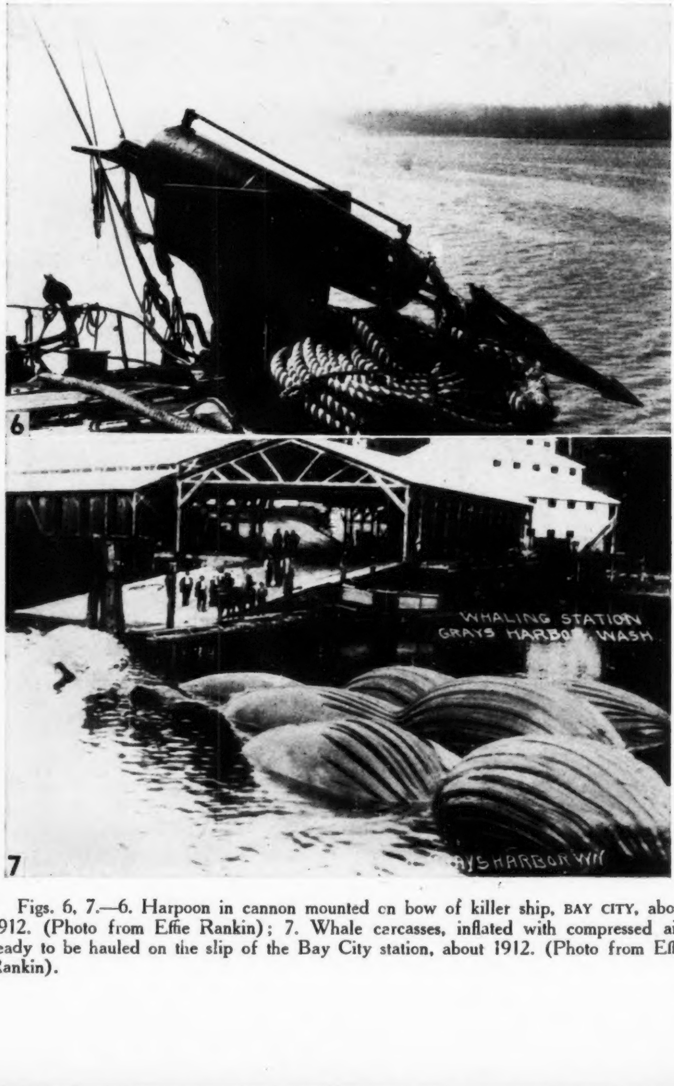
At no time was there a shore station on the Oregon coast, although whaling ships based to the south and north often hunted in Oregon waters. The first station to operate in British Columbia was established in 1905 at Sechart, Vancouver Island (Whale Products Company, 1907?, p. 7). A station at Naden Harbor last operated in 1941 and one at Rose Harbor in 1943. These two stations in the Queen Charlotte Islands were owned by the Consolidated Whaling Corporation, Ltd., of Victoria, an affiliate of the American Pacific Whaling Company of Bellevue, Washington. The latter company built and operated the whaling station at Bay City, Washington, from 1911 to 1925. This firm was known for the first few months of its life in 1910 or 1911 as Hall and Company, according to Victor H. Street.

The history of the Bay City station as revealed by annual catch figures (Table 1) is a story of early success followed by diminished but still profitable catches until the advent of pelagic whaling by Norwegians off Lower California in the winter of 1924-1925. Located on the south side of Grays Harbor about 6 miles from the ocean by water, the station was served by four 88-foot Norwegian killer ships, or whale catchers: the ABERDEEN, WESTPORT, MORAN, and PATTERSON (Figs. 4-7). These were steam-driven oil burners of 116-120 gross tons, with a cruising speed of 9.5 knots and a maximum speed of 11 knots. The normal crew of each ship included master, mate, cook, 2 engineers, 2 able-bodied seamen, and 2 ordinary seamen—9 in all. Equipment at the shore station included: a landing slip in two sections, leading to a carcass platform about 40 x 100 feet, bordered by wooden cooker vats and skimming troughs; blubber apparatus consisting of a slicer, endless belt elevator, eight 10-ton blubber pots, and a centrifugal separator; 2 haul-up winches and 1 canting winch, and a number of pumps and hand tools, such as crosscut saw and flensing knives. The whales were rendered by steam from a central oil-burning plant which also powered the various machines.

The plant was manned by a maximum of 50 workers including a foreman, chief engineer, assistant engineer, timekeeper, weigher and checker, 2 flensers, 2 hookmen, 2 winch operators, meat cutters (butchers), and blubber cutters. Wages for the shore crew were at a flat rate, without the bonus per whale which was given to men on the killer ships.

Conventional whaling methods were employed. After death the whale was inflated, marked with a pole and flag, and set adrift until the day's hunting was over, when it was towed back to the station. The flukes were cut off with a long-handled cutting spade and a cable was looped around the tail. At the station, the carcass was tied to a buoy to await processing, which began as it was hauled, tail first, to the platform at the top of the first section of the slip. Here the harpoon was cut out and the viscera were removed. A second winch then drew the carcass to the upper platform where it was flensed and dissected, the carcass being manuevered by 2-pronged "devil's claws" attached to deck chains and the cable of a canting winch. The skull was sectioned with a cross-

cut saw. Meat and bone went into the cooker vats along the sides of the platform, while spermaceti was ladled into collecting troughs running the length of the platform to a vat. The blubber masses were drawn ahead to a chopper or slicer consisting of 2 blades on a cast-steel disc 5 feet in diameter, set in the floor. The resulting pieces were carried by belt elevator to the blubber pots which drained by 8-inch pipes to the centrifuge.



Figs. 6, 7.—6. Harpoon in cannon mounted on bow of killer ship, BAY CITY, about 1912. (Photo from Effie Rankin); 7. Whale carcasses, inflated with compressed air, ready to be hauled on the slip of the Bay City station, about 1912. (Photo from Effie Rankin).

The killer ships usually operated south of Cape Flattery along the Washington coast, making longer trips to southern Oregon (Cape Blanco) and Vancouver Island when necessary. Thus the radius of operations was about 135 miles. Rivalry among the killer ships was fostered by a bonus system. Record catches for the five seasons of 1913-1915 and 1918-1919 were: largest month's catch by a single ship, 30 whales; largest single day's catch, 4 whales. The latter figure was attained seven times during the five years with humpback whales, and once with 3 humpbacks and a finback. Of no other species than the humpback were as many as 4 taken in a single day by one ship. Six sperms (3-2-1) were taken by three ships on October 14, 1919. "Pacific Fisherman" reported that 3 sperms were brought in by one boat as a day's catch in the summer of 1916 (v. 14, p. 34). On the basis of catch efficiency, the take at Bay City was generally better than the average take of the 5 to 10 contemporary stations along the coast between Alaska and California.

Catch records of the Bay City station, insofar as we have been able to obtain them, are summarized in Table 1. Data are mainly from Radcliffe (1933, pp. 28-33, Table 2), who obtained his own data from reports of the U. S. Bureau of Fisheries and "Pacific Fisherman." We have made certain annotations and corrections on the basis of figures in Kellogg (1931), files of "Pacific Fisherman," and certain manuscript records loaned by the American Pacific Whaling Company. *Catch* figures from the various sources are sufficiently alike to permit tabulation, but *production* figures are rather incomplete and, in some cases, at variance. The figures appearing in our tables are the ones which we consider most probable.

Detailed records, including monthly catches by species, are available for only 5 years (1913-1915, 1918-1919) owing to the loss of many records of the Bay City station in a fire in 1935. As summarized in Table 2, the records indicate that the number of whales increased steadily during the season to a peak in August and declined thereafter. The overall trend was weighted heavily by the trend of the most abundant species, the humpback. The influence of the finback on the total catch was revealed in the July slump. The midsummer concentration of whales, mostly humpbacks, along the Washington coast was reflected by the increased number of ships employed and the increased efficiency per ship (Table 1).

The length of the working season at Bay City varied somewhat from year to year, beginning from April 14 to April 27 and ending from September 13 to October 19 in the five years for which detailed records are available (Table 1). Evidently an earlier starting date was tried in 1912, as "Pacific Fisherman" reported a "California humpback" taken March 14 as the first whale of the season (v. 10, p. 24). Whaling during the winter months was not practiced because whales were scarce and the weather was uncertain.

No figures are available on the market value of the Washington catch. More regrettable from a biological point of view is the lack of information on sizes, sexes, and embryos of Washington whales.

Species Accounts*

Order CETACEA, WHALES AND DOLPHINS

Suborder Odontoceti, Toothed Whales and Dolphins

Family ZIPHIIDAE, BEAKED WHALES

The whales of this family are little known. Three genera: *Mesoplodon, Berardius*, and *Ziphius*, are reported from the northeastern Pacific. A fourth, *Hyperoodon*, is recorded from Asiatic waters (Arsenyev and others, 1937; Tanaka, 1934; Tomilin, 1938; Zenokovič, 1937). Only *Mesoplodon* is definitely recorded from Washington, although the presence of more than one beaked whale here is indicated by whaling statistics, photographs, and popular descriptions. For convenience in presenting our information on beaked whales we have listed them under specific names.

BERARDIUS BAIRDII Stejneger 1883—Baird Beaked Whale

A female, apparently of this species, was stranded on the ocean beach between Queets and Kalaloch, in the spring of 1939. Someone photographed it and gave two prints to Dale Northrup, of Copalis, who forwarded them to us.

It is interesting to speculate on the identity of 8 "bottlenose whales" reported in the kills of the Bay City whaling station. The Atlantic bottlenose, *Hyperoodon ampullatus* (Forster) 1770, is unknown in the northeastern Pacific; of the three other genera of beaked whales only *Berardius* is large enough (up to 41 feet) to be a worthwhile target for whalers, although *Ziphius* might occasionally be taken. Unfortunately, we have little information on the Bay City animals. Victor H. Street recalled the bottlenose as comparable in size to the gray whale and colored a "humpback black." Axel Weidquist, gunner, told us that the bottlenose was a "species of sperm" with a long snout and only a few teeth. Andrew Falkwood said that the bottlenose whale was like a small sperm; it definitely had more than two teeth but whether these were in one jaw or both he did not recall. The head was "shaped like a bottle." He also supplied a sketch showing the shape of the head, with the statement that the animal was about 30 or 35 feet long, gray in color, with an oil content of about 25 barrels.

That the whale was of considerable size may be inferred from the Bay City production records for 1918 and 1919. In 1918, three bottlenoses were taken and 39 barrels of bottlenose oil were included in the sperm oil returns. In 1919, one bottlenose yielded 13 barrels of oil. It is inconceivable that whales shorter than 30 or 40 feet could have produced as much oil, thus making it reasonably certain that the bottlenose whale captured were, indeed, *Berardius*. The four kills of bottlenose whales in 1918 and 1919 were distrib-

* For each species, records are listed in chronological order. Measurements are in millimeters unless otherwise stated. The following abbreviations are used: AMNH, American Museum of Natural History; MVZ, California Museum of Vertebrate Zoology; USBS, U. S. Fish and Wildlife Service, Biological Surveys Collection; USNM, U. S. National Museum; WSM, Washington State Museum.

uted through the whaling season: one each in April, May, July, and September (Table 2).

MESOPLODON STEJNEGERI True 1885—Stejneger Beaked Whale

The fresh carcass of a beaked whale was reported stranded on the ocean beach at the mouth of the Waatch River, Clallam County, in February, 1942. We examined the skeletal remains on June 7 and preserved nine of the vertebrae, together with the skull, lacking teeth, mandibles, and certain other parts (AMNH 143829; original VBS 1274, sex?). The curvilinear length of the skeleton *in situ* was 449 cm. Taking into consideration the few caudal vertebrae which were missing and the original thickness of the terminal cartilages, the standard length of this whale in life was not greater than 5 meters.

The specimen was first called to our attention by Fred Irving, an educated Makah native, who commented on the find in words somewhat as follows:

"This is *kwow-kwow-e-acht-le,* or 'noisy tail.' The back is not sharp, high, or raised, and the dorsal fin is small and curved backward. The body is all black, or perhaps with some gray on the belly. The natives once tried to eat the blubber and flesh but it caused diarrhea. This kind is seen swimming near Neah Bay and is not afraid of canoes. It is seen one-half to one mile offshore on the salmon trolling grounds; only one, two, or three whales together. It blows once or twice between soundings."

A second fragmental specimen of *Mesoplodon* was recovered from the ocean beach at Oyhut, on November 2, 1944, by Paul M. Scheffer. It consists of one vertebra and the cranium; lacks teeth, mandibles, and portions of the beak and occipital region (USBS 32000 X: original VBS 1306, sex?).

Bailey stated that up to 1936 only two specimens of *Mesoplodon stejnegeri* were known to science (1936, p. 345).

Scammon's "Puget Sound Grampus" is quite possibly this species. Thus, "in Port Townsend Bay, Washington Territory, June 19th, 1868, a great number of small whales, evidently a species of grampus, were seen gamboling, in squads of six or eight individuals, whose movements were similar to those of the blackfish (*Globiocephalus*). They were likewise of the same jet-black color; but the dorsal fin was narrower, very pointed, and placed about one-fourth of the animal's length from its flukes. So far as our observations go, the Puget Sound grampuses are not numerous, and they are but rarely seen about the inland waters in Washington Territory, which is the only place where we have met with them." (1874, p. 105.)

P. G. Putnam told us of a group of 3-5 long-beaked "porpoises," with heads a foot in diameter, seen by him about 5 years earlier in Puget Sound. They behaved curiously, holding their heads up above water for periods of a few seconds as if staring at him. The profile as described and sketched showed a very pronounced beak and high "forehead." His account as a whole suggested *Mesoplodon.*

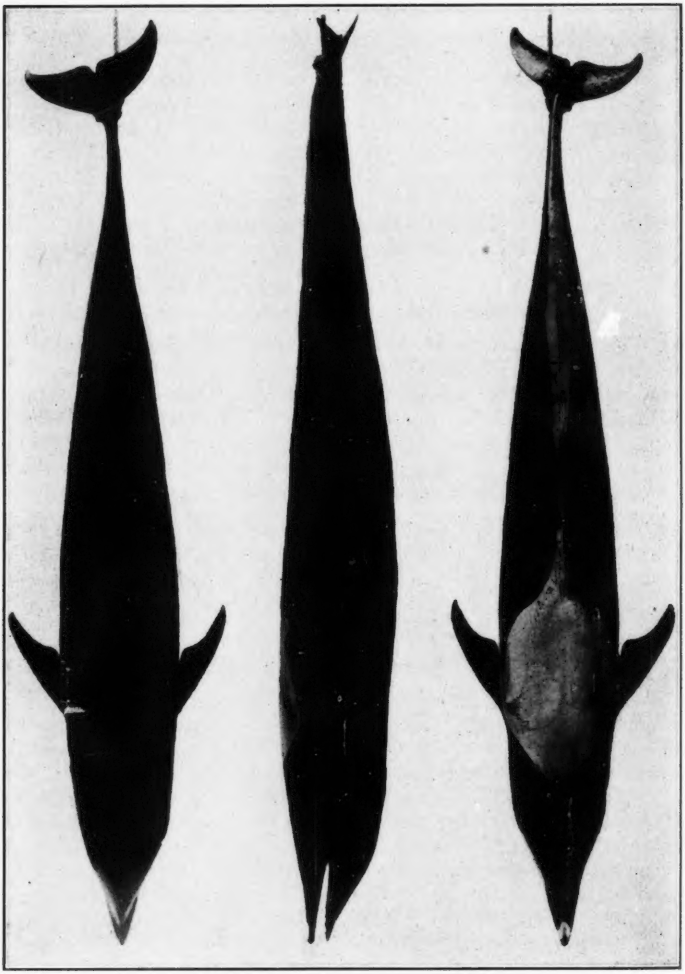


Fig. 8.—Right whale dolphin from Copalis, March 11, 1940. Specimen VBS 825, male. (See p. 269).

Family DELPHINIDAE, TYPICAL DOLPHINS

DELPHINUS BAIRDII Dall 1873—Baird Dolphin

This species is included on the evidence of a photograph, taken by Peter J. Smith, of a porpoise which was stranded at Pacific Beach in February, 1942. Mr. Smith told us that the animal was dark gray above and light gray below. Someone removed the body on the assumption that it was a shark and that its liver was valuable. Reference is made on page 323 to a dolphin of uncertain identity that should perhaps be assigned to *Delphinus*.

LISSODELPHIS BOREALIS (Peale) 1848—Right Whale Dolphin

Gordon Alcorn found a specimen, injured on the belly, on Cohassett Beach, 2 miles south of Westport, October 15, 1939. He prepared the skeleton as a demonstration mount for students at Grays Harbor Junior College, Aberdeen (GA 5-20, male). We photographed it and took certain measurements on May 21, 1942 (Fig. 9). The distance between verticals dropped to the platform from the tip of the last caudal vertebra and the tip of the rostrum was 212 cm, representing a body length of about 7 feet in the living animal. The skull measured: total length 449, basilar length 441, length of beak to level of bases of maxillary notches 258, breadth of beak at bases of notches 115, length of maxillary tooth row 220, length of mandible 377, length of mandibular tooth row 226. Dentition: UR 46 - UL 47, LR 48 - LL 49.

Another right whale dolphin was found on the ocean beach at Copalis, March 11, 1940, by Wilbert M. Chapman (1940, p. 10). The fresh carcass was examined by one of us on the following day and the skull was preserved (USNM 270981; original VBS 825, male). Weight 124 pounds (56.2 kg); snout to base of tail notch 2,078; girth behind flippers 820; center of anus to base of tail notch 497; between tips of tail flukes (not maximum width) 312; curvilinear length of forward edge of flipper 290; depth of tail notch 21; eye opening 13 x 24; maximum width of blowhole 25; mandible extending 8 mm beyond snout; thickness of blubber 10-15. Color: black above and black-and-white below, white on tail flukes poorly outlined; white throat patch about 45 mm long. (Fig. 8).

The stomach and intestine were empty save for a single, small, squid beak in the stomach. Several grub-like parasites, probably tapeworm cysts, creamy-white to yellow, were imbedded in the perianal blubber.

Skull measurements: total length 422, basilar length 418, length of beak to level of bases of maxillary notches 229, breadth of beak at bases of notches 112, length of maxillary tooth row R 200, length of mandibles R 366, L 368, length of mandibular tooth row R 196, L 193. Dentition: UR 43 - UL 43, LR 44 - LL 42. We believe that a number of small teeth which originally rested in fleshy alveoli are missing from the tip of the maxilla and, as a consequence, 43 is a minimum count. Similarly, missing teeth would probably bring the count for the mandible to 45.

The type specimen of *Lissodelphis borealis* was taken a century ago by

Peale about 500 miles off the mouth of the Columbia River, and few specimens have been preserved since.

". . . To this species, Mr. Peale alludes as follows: 'While in the water it appears to be entirely black, the white line being invisible. It is remarkably quick and lively in its motions, frequently leaping entirely out of the water, and from its not having a dorsal fin, is sometimes mistaken for a Seal. Specimens were taken in the North Pacific Ocean, latitude 46°6′50″, longitude 134°5′ W. from Greenwich. Great quantities of a species of *Anatifa* were floating on the surface of the sea, on which they were probably feeding [*?Lepas fascicularis*, a pelagic barnacle]. Two, which had been struck and badly wounded with the harpoon, escaped, but the others did not leave the ship as the *Delphini* usually do when one of their number is wounded.' From the latitude and longitude given by Mr. Peale, it will be found that the land nearest to the point at which this animal was obtained is the coast of Oregon [Territory]." (Cassin, 1858, p. 31.)

LAGENORHYNCHUS OBLIQUIDENS Gill 1865—Striped Dolphin

A specimen consisting of the anterior half of the cranium with about three-fourths of the teeth, was collected in Puget Sound by George Suckley and catalogued March, 1854, in the National Museum as no. 3123.

C. T. Larsen, former master of the University of Washington research vessel CATALYST, says that striped dolphins were freqeuntly encountered in the Strait of Juan de Fuca and off the coast, at least during the summer months when he visited these waters. Harriet Geithmann has published a photograph with the title, "Captain C. T. Larsen with a 500-pound porpoise which was harpooned just outside Cape Flattery and west of Vancouver Island" (1935, p. 80). Miss Geithmann does not recall the source of the photograph but believes that it was furnished by Robert C. Miller in 1933 or 1934. We estimate the length of the specimen at 6 feet and the weight 200-250 pounds (Fig. 10).

Another striped dolphin from Washington has been described in a note which we quote in full: "On September 17, 1936, while the oceanographic motorship 'Catalyst' was making its monthly trip in the Strait of Juan de

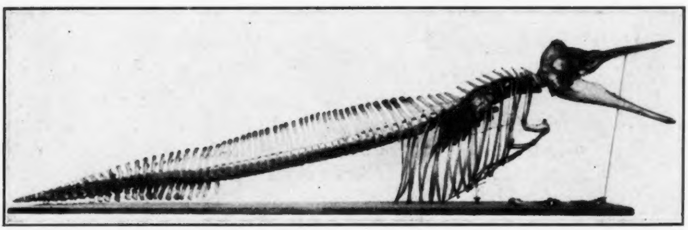


Fig. 9.—Right whale dolphin from Cohassett Beach, October 15, 1939; skeleton prepared by Gordon Alcorn and students. Specimen GA 520, male. (See p. 269).

Fuca to carry on certain research work, a school of porpoises (*Lagenorhynchus obliquidens* Gill) played around the bow of the boat. One was harpooned and hauled onto the deck. This female specimen was about six feet long and weighed about 300 pounds. When dissected a 22 mm. embryo was taken from the uterus. This embryo is regarded as a prize specimen of its kind" (Guber-

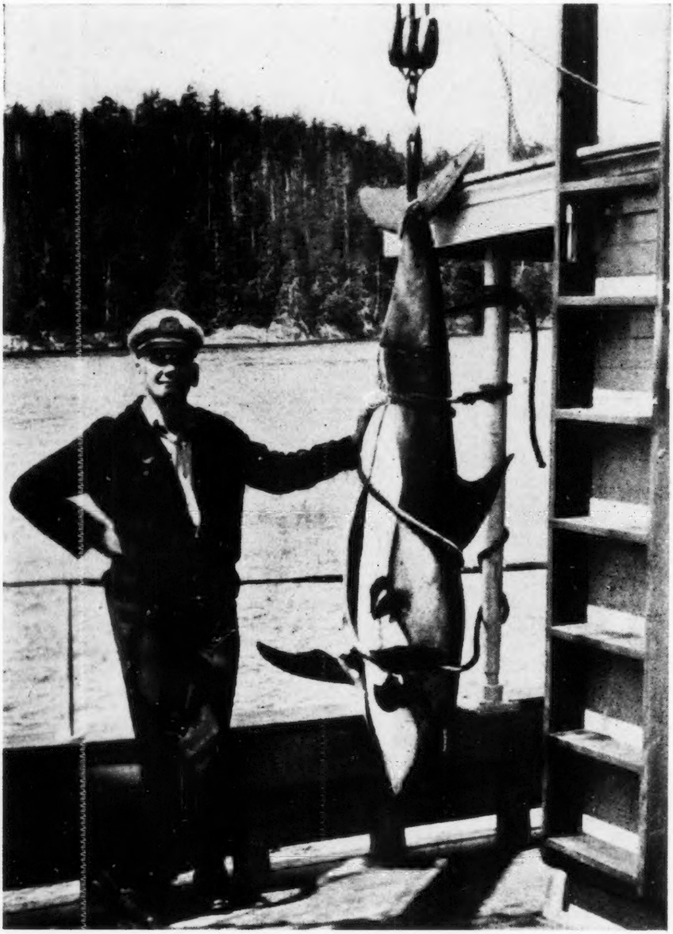
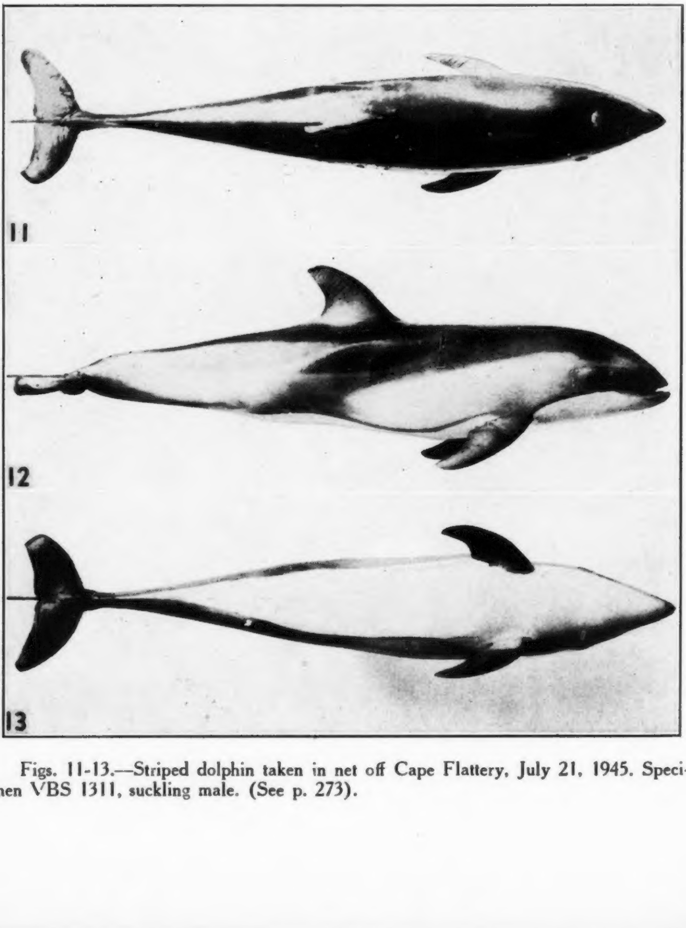


Fig. 10.—Striped dolphin harpooned off Cape Flattery, about 1933 or 1944. (Photo from Amer. Mus. Nat. Hist.). (See p. 270).

let, 1936, p. 56). Captain Larsen examined the ship's log and told us that he harpooned this porpoise off Race Rocks Lighthouse, middle of Strait of Juan de Fuca, on September 17, 1936. It had a "black back and white belly; a very distinct line separating the black and white."

A vial of worms in Guberlet's collection labelled "Nematodes—alc.—stomach, pyl. Porpoise, Sept. 18, 1936" undoubtedly came from the same specimen. Through the kindness of John Rankin we obtained the embryo, now specimen VBS 1263, sex? In alcohol, on March 30, 1942, it had a crown-rump length of 12.9 mm; thus the length as reported by Guberlet was evidently curvilinear.

Walter W. Dalquest has the skull of a striped dolphin harpooned from the CATALYST by Cameron Knox, 50 miles off Grays Harbor, August 17, 1939. Mr. Dalquest has kindly offered his field notes describing the specimen



Figs. 11-13.—Striped dolphin taken in net off Cape Flattery, July 21, 1945. Specimen VBS 1311, suckling male. (See p. 273).

(WWD 1569, sex?). Original measurements were in inches, which we have changed into millimeters, and were in some cases accompanied by sketches describing the exact way in which they were taken. "Length 56¾ [1441], width tail 20½ [520, probably maximum width], height of dorsal 7⅝ [193], length of dorsal 13½ [342 in a straight line from tip to anterior angle, that is, insertion], pectoral along angle 23⅜ [593 in a straight line from tip to anterior angle], width of pectoral 4½ [114]. Tail and upper parts jet black; 2 grayish-black streaks on hips; underparts—anus to chin—white; pectorals all black, greatest width of white underparts 8 inches [203]." Measurements of skull: total length 372, basilar length 367, greatest breadth (zygomatic) 193, length of maxillary tooth row R 171, L 168, length of mandibles R 315, L 317. Dentition UR 31 (32?) - UL 31 (32?), LR 29 (30?) - LL 29 (30?).

L. V. Stevens found a striped dolphin on the beach at Ocean Park on May 3, 1942. It was alive but had a small hole in its cranium. Mr. Stevens positively identified it as a male. We examined the carcass on May 10: length from snout to base of tail notch 1797, maximum width of flukes 392, between tips of flukes 373. The broken skull was saved (USNM 270980; original VBS 1265). (Fig. 14).

A striped dolphin in putrid condition was found by Paul M. Scheffer on the ocean beach at Oyhut, November 2, 1944. The body was said to be 6 feet [1828 mm] from snout to base of tail notch. The skull has been saved as USNM 274627; original VBS 1305, sex? Measurements: total length 387, basilar length 379, greatest breadth (zygomatic) 195, length of maxillary tooth rows: R 186, L 178, length of mandibles: R 325, L 325. Dentition: UR 30 - UL 30, LR 30 - LL 30. The tooth counts are only approximate, since a few small teeth were lost in the process of cleaning the skull.

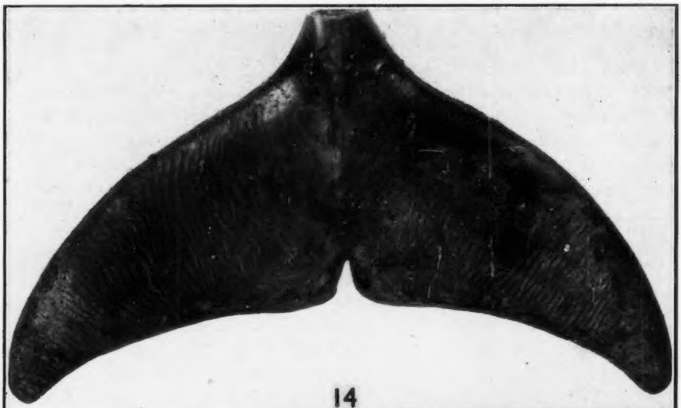
A young striped dolphin was captured in a shark net near the surface of the sea 35 miles south of Cape Flattery on July 21, 1945, by Jacob Bassi. We examined and photographed the frozen carcass on September 13 (Figs. 11-13, 15) and saved the skull and pelvic rudiments. (USBS 32316X; original VBS 1311, male). Weight 65 pounds (29.5 kg); snout to base of tail notch 1240; girth behind flippers 732, maximum width across tail flukes 340; snout to tip of dorsal fin 788; snout to insertion of flipper 312; axillary length of flipper 164; maximum width of flipper 75; height of dorsal fin 125; tail notch to center of anus 338; tail notch to center of umbilicus 634; tail notch to middle of genital slit 446; length of slit about 70 (plus an additional 30 mm groove grading to a flat surface at the anterior end); corner of mouth to snout 165; corner of mouth to middle of lower lip 171; snout to center of eye 196; dimensions of eye opening 11 x 16; snout to transverse slit of blowhole 801; maximum transverse width of blowhole 27.

The specimen was judged to be suckling, since its stomach held a small amount of curdled milk and nothing else. Maxillary dentition included 34 pairs, of which the first 12 pairs and the last 3 pairs had not yet erupted. Mandibular dentition included 30 pairs, of which the first 15 pairs had not yet erupted. Counts of teeth are approximate.

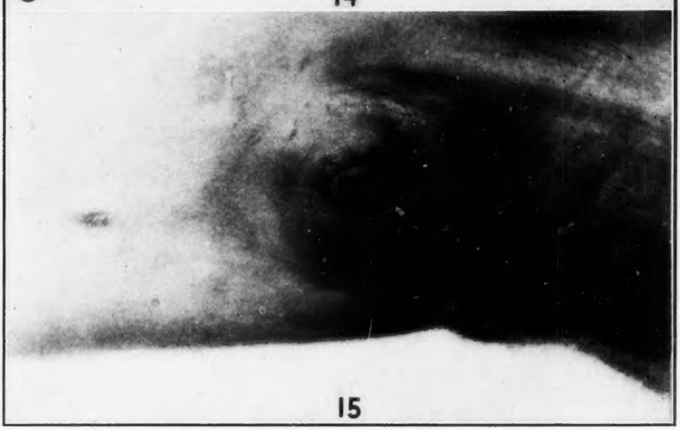
Measurements of skull: total length 281; basilar length 271. Dentition: UR 31? - UL 31?, LR 31 - LL 31. Length of right and left pelvic rudiments, 16 and 15 mm.

GRAMPUS RECTIPINNA (Cope) 1869—Killer Whale

Occurrence.—In marine waters of the state at all seasons, gregarious, roving; frequently seen in the Strait of Juan de Fuca and Puget Sound and off the Olympic seacoast, perhaps less common farther south on the coast and



14



15

Figs. 14, 15, Striped dolphin.—14. Ventral view of tail flukes; maximum spread 398 mm. Specimen VBS 1265, male. (See p. 273); 15. Detail of right eye and ear. Dimensions of eye opening 11 x 16 mm.; distance from center of eye to ear opening (at left) 60 mm. Specimen VBS 1311, suckling male. (See p. 273).

in the Columbia estuary; in the Sound region somewhat more common in the northern waters, congregating, especially in summer, at the mouth of the Fraser River, in Georgia Strait, Washington Sound, and off Camano Island during salmon and herring runs; apparently more frequent and regular in the spring and fall months at Tacoma and southward in Puget Sound, but recorded there at all seasons; said to appear rarely in Willapa Bay.

Specimens.—Killer whales are known in the Puget Sound region as "blackfish" (not to be confused with *Globicephala*, p. 289). They are often seen by persons living and working along the coast of Washington but it is rarely that a naturalist has opportunity to examine a specimen close at hand. Although occasionally shot at by sportsmen and fishermen, adult killers are sufficiently strong, active, and wary to avoid capture by ordinary means. The Bay City whalers considered the animal too small and lean to be worthy of pursuit, as did the Quillayute natives, but the Makah are said to have hunted it successfully and to have prized its flesh as food (Scammon, 1874, p. 92). Heizer states that "the killer whale is notoriously easy to kill" but "was never hunted commercially by deep-sea whalers" (1943, p. 457). Occasionally killers are trapped in shallow water or in the nets of fishermen and thus become available for study, as described in the following accounts:

San Juan Island, summer of 1929.—A killer whale entered a salmon trap at False Bay, was shot by the trap guard, and drifted a few miles south to a bay near Cattle Point, San Juan Island, where it was examined on June 23 by a group of students and teachers from the old Puget Sound Biological Station. J. E. Guberlet saved some nematodes (JEG 879:448) from the stomach. His accompanying notes state that the liver was small—the size of a man's fist—and there were about 5,000 nematodes in the stomach in addition to greenling, ling cod, salmon, and squid; body length 12 feet.

Stanwood, about 1930.—From the reports of game protector Ole Eide and others it is known that a "blackfish" was killed on the Stanwood flats. No photographs or fragments are available.

Vancouver, October 24, 1931.—A female killer whale "thirteen and a half feet in straight line from tip to tip" ascended the Columbia River for a distance of 110 miles and was eventually killed opposite Vancouver, Washington, on October 24, 1931 (Shepherd, 1932). Newspaper accounts of the whale were given in the "Morning Oregonian" (Portland) as follows: October 13, pp. 1 and 5, 1 photo; October 26, pp. 1 and 11, 2 photos; October 29, pp. 1 and 11, 1 photo. The men who killed the whale with handmade harpoons, Edward O. and Joe Lessard, were arrested for the use of illegal tackle in taking a "fish" but were later released. Disposal of the carcass, which had been embalmed (Fig. 31), was still a court issue eight years later (Portland press reports, August 5, 1939).

Vancouver, October 30, 1940.—Two killer whales were seen in the Columbia River near Vancouver, and Les T. Ordeman obtained a clear photograph of one. In the "Oregon Journal" (Portland) of this date the statement

Fig. 16.—Killer whale captured in the Columbia River near Vancouver on October 24, 1931; subsequently embalmed; photographed at the Multnomah County (Oregon) court house on December 6, 1931, by M. W. Werschkul. Female; length about 13.5 feet. (See p. 275).

appeared that the whales were cavorting near Swan Island and were each about 20 feet long.

Camano Island, summer of 1940 or 1941.—Ed Sierer of Tulalip recalled fishermen's stories of a 7-foot whale calf which drowned in a net near the island and was left on the beach to rot. It was said to have the coloration of an adult killer.

St. John's, Columbia River, March, 1942.—In the "Sunday Oregonian" (Portland) of March 15, 1942, p. 7, there appeared a photograph of the dorsal fin and part of the back of a whale, probably, but not certainly, a killer. The caption stated that "this one was sighted sporting near St. John's" in the Columbia River.

Copalis Beach, May 20, 1942.—We recovered the abraded skull of a killer whale from the premises of Fritz Menath, and were told that the animal, 20-25 feet long, washed in during the summer many years before (WSM 12509; original VBS 1271, male?). The greatest (zygomatic) breadth of the skull is 636 mm. This, incidentally, is our only specimen of the killer whale from Washington.

Hat Island, Snohomish County, July 30, 1943.—A juvenile female became entangled in a floating gill net set for salmon off Hat Island and was recovered dead on the morning of July 30. Kelshaw Bonham and C. H. Baltzo

Fig. 17.—Killer whale; young female drowned in fish net at Hat Island, Snohomish County, July 30, 1943. (Kelshaw Bonham photo). (See p. 277).

Fig. 18.—Killer whale; young female drowned in fish net at Hat Island, Snohomish County, July 30, 1943. (Howard Baltzo photo). (See p. 277).

examined the animal on August 1 and took several photographs (Figs. 17-20). According to Mr. Baltzo, the entire alimentary tract was empty save for slime and parasitic worms. We obtained a sample of the worms and sent them to Alden McIntosh of the U. S. Bureau of Animal Industry, who identified them as *Anisakis* sp. (Worms of this genus occur also in the sperm whale.)

Ed Sierer, owner of the dock where the killer whale was dissected, obtained the following measurements: length from snout to entrance of tail notch 13 feet, 1 inch [this would be 1-2 inches longer than the standard length]; greatest girth 7 feet, 6 inches; width across flukes 27-28 inches.

Aside from about one-half liter of stomach worms, no parts of the Hat Island whale were saved. A newspaper account of the capture was given by Bradner (1944).

The specimen was a juvenile, with undeveloped ovaries and teats, and may have been attending its mother, since for three days after its death a single, large killer was said to be wandering in the vicinity of Hat Island.

Mr. Baltzo distributed samples of the flesh of the whale to several persons who later reported on its flavor. It tasted like liver, palatable to some but not to others. Baltzo, himself, was moderately pleased with the freshly cooked meat but not with the meat after it had been frozen and cooked. His dog accepted meat which was frozen and subsequently thawed and canned.

Cherry Point, Vancouver Island, B. C., September 28, 1944.—G. Clifford Carl, director of the Provincial Museum, Victoria, has kindly supplied photographs and measurements of a suckling female killer stranded at Cherry Point, on the east coast of Vancouver Island, due west of Bellingham, Washington. Measurements: total length 8 feet, 1 inch; across flukes 24 inches; vertical height of dorsal fin 11 inches, length of flipper 13 inches; girth 4 feet, 7 inches. Umbilicus still evident; teeth not yet through gums. The skull is in the Provincial Museum.

Miscellaneous records.—Harold Kimball and Ralph Quistorff, ferry operators of Gig Harbor, reported that a "blackfish" was trapped years ago in a slough at Burley (head of Henderson Bay). It could not be killed by rifle fire and escaped on the next tide. The story was later verified by John Finfrock of Burley.

L. M. Olson recalled that about April or May of 1921 a robust, smooth, brownish-black whale about 26-30 feet long, with broad, paw-like flippers became trapped behind the dock at DuPont at night, and was found by workmen in the morning. It escaped through the piling about noon, after much thrashing. Olson could not describe the dorsal fin but the other features were evidently those of a killer.

A "blackfish" 12-14 feet long was stranded for a while near the bar in Willapa Bay, according to E. P. Nelson of Ocean Park.

General characteristics.—To supplement the meager data available from specimens we have recorded the observations of reliable persons who have

Figs. 19, 20.—Killer whale; young female drowned in fish net at Hat Island, Snohomish County, July 30, 1943. (Howard Baltzo photos).

seen various activities of killer whales. The abundance, inshore habits, and spectacular traits of the animal have enabled observers to learn more about the killer whale than perhaps any other Washington cetacean (Fig. 21).

The most striking feature of the killer is its high, triangualr to sickle-shaped dorsal fin, from less than 2 to perhaps 6 feet in height. In a given school of killers there are generally more low-finned individuals (females and young) than high-masted old males. One informant, Erling Bergerson, Tacoma sportsman, estimates the ratio at roughly 10 of the former to 1 of the latter. The length of the body in old males has been variously estimated as 25 to 35 feet. A digest of the numerous color descriptions obtained by interview and direct observation reveals that the usual type of coloration among killers of all sizes and both sexes in Washington waters is similar to that of the Atlantic *Grampus orca,* that is, white ventral trident, and white, or rarely, yellow, oval spot behind the eye, on a black ground (Fig. 16). The obscure saddle marks reported for certain Atlantic and Pacific specimens are vaguely evident in photos of the Hat Island specimen, and were noted on specimens in a school at Tacoma, November 16, 1945. A big male observed through glasses at Tacoma, November 16, 1941, was apparently all black. George Rodgers has had unusual opportunities to see killers at close range from his tug in the Deception Pass region. He states that some are definitely

Fig. 21.—Killer whales in Puget Sound near Point Defiance, Tacoma, on August 13, 1947. (Aero-Marine Photos).

all black, and that, on January 2, 1942, he saw a school containing one that was *all white*, about 10-12 feet long, and smaller than its companions.

The "Pacific Northwest Sportsman" reported on March 22, 1946, that "the skipper of the M/V Osage which carries freight between Bellingham and Friday Harbor saw a small school of blackfish and in the school was a white one."

Habits.—The "wolf pack" nature of the killer whale is well known to residents of Puget Sound northward to Georgia Strait, where most of our information has been obtained. Here, in bands of 3 to 60 or more, killers range in all months of the year, rarely, if ever, remaining more than a few minutes or hours in any one place. At favored places and seasons, e. g., Tulalip Bay in summer, their visits may be regular and frequent.

Killers are known to travel and to feed in the dark and seem to be especially active inshore, feeding in the shallows and in river mouths after nightfall. Most of the known strandings have taken place at night. E. Zukowski and J. Sheriff independently reported seeing, in the spring of 1942, the temporary stranding of a killer whale on the beach near Point Defiance, Tacoma. The animal was thought to be driving herring inshore at night. Years ago, T. D. Van Slyke and companions tried gill netting in the mouth of the Nisqually during a salmon run. About 9 p. m. they were frightneed away by killer whales splashing and churning the shallow water within 75-100 yards of their boat.

Nothing certain is known of the resting habits of the killer. Harold Kimball and Ralph Quistorff, operators of the large and noisy Point Fosdick ferry, stated that on one occasion, the ferry narrowly avoided colliding at night with a floating killer.

Swimming, breaching, and blowing.—On November 16, 1941, we watched from the Tacoma waterfront a school of killers swimming and sporting in Commencement Bay. While some played off Browns Point, sending up great splashes visible for miles across the water, a huge black male continued toward the head of the bay, swimming submerged most of the time but rising at regular intervals to breach (i. e., break the surface) and blow three or more times before sounding. As seen through binoculars, each rise progressed as follows: (1) snout and tip of dorsal fin appeared together as whale approached surface at a low angle; (2) spout was delivered when at peak of rise, body exposed from near jaw to base of dorsal fin; (3) forward roll brought dorsal fin erect, back exposed from about blowhole to a point behind dorsal fin; (4) dive was executed as continuation of forward roll, descent being at a steeper angle than ascent, tip of dorsal during entire process describing a low parabola. The rise lasted about 5 seconds. Approach of the killer sent rafts of ducks in its path into flight.

Exactly four years later another school was watched at close range in the same waters. In this case 6 to 10 smaller whales (adult females and young) passed and foraged within 100 yards of the pavilion at Point Defiance. These appeared to be about 15 feet long and had dorsal fins a scant 2 to 3 feet high. None were enitrely black. Each whale followed a straight course of

about 40 yards before it sounded. Along this course it commonly rolled (breached) 3 to 5, usually 4, times. The interval between rolls was about 5 seconds and the duration of each roll 2 to 5, usually 4, seconds. Larger animals (probably adult males) farther out seemed to be rolling more slowly. The pattern of each rise was similar to its predecessor, with no distinction in the last, or pre-sounding roll. Four phases were distinguished: (1) snout and tip of dorsal fin erupted, spout delivered instantly; (2) animal rolled out, exposing upper body from near end of snout to well back of dorsal fin (*cf.* Fig. 21), upper markings well above water; (3) back arched, dorsal fin at top of curve, head depressed; (4) tip of dorsal fin and caudal peduncle disappeared, flukes did not emerge, a subsurface straightening of the body indicated, angle of descent similar to that of ascent.

A killer will occasionally travel at the surface with its back awash, instead of alternately diving and breaching. An instance where "two went by on the surface, swimming side by side" was related by George Rodgers, of Deception Pass.

Ed Sierer has freqeuntly observed killers from a power boat at close range in Tulalip Bay, and has attempted to capture them. He states that, when travelling unalarmed, they appear with regularity at 5-minute intervals, surfacing 4 times before sounding. In play or in alarm, their power and speed is tremendous. They may jump vertically so that the tail reaches a point 8 feet above the water! On fast, low jumps they cover 40 to 45 feet; Sierer saw one about 22 feet long "jump approximately 40 feet and clear the water by 5 feet." On one occasion he rushed into a school of about 60 with his motorboat, but was soon persuaded to retreat by the speed and erratic maneuvers of the big animals.

The speed at which killers normally travel is estimated by Sierer at 8 to 10 miles per hour. He followed, at a rate of about 4 miles an hour, a feeding school in which the individual animals were constantly changing course. "The top speed must be great because, while travelling with the school in Deception Pass at 15 knots, we've been passed at double our speed, or better." Rodgers has seen them successfully breast the running current through narrow Deception Pass, a feat beyond the power of most motorboats on the Sound. Two "30-foot whales [which] charged past two commercial fishing boats [in the Columbia River] at better than 18 miles an hour, tore up two fish nets and proceeded upstream" were probably killers. They were pursued unsuccessfully by fishermen who found their boats "not fast enough to follow them" (Cathlamet, Oregon, press report, October 30, 1940).

The blow or spout of the killer is said by Rodgers to rise 15 to 20 feet under favorable conditions. A big male cruising up Commencement Bay in the face of a brisk wind, November 16, 1941, spouted about as high as its dorsal fin. In a mild breeze smaller animals blew 5 to 7 feet high, the vapor forming bushy puffs on the breeze. Residents and fishermen along the Sound often follow the night movements of killer schools by the sound of the blowing, a quick breathy puff, louder and sharper and lacking the double gasp of the harbor porpoise.

Playing and fighting.—Schools of killers are often seen in spectacular surface play. Many of their displays, seen from afar, are probably courting or foraging activities, while others seem to be pure sport. For example, on Labor Day, 1941, Thornton Mock watched a number of killers playing a half-mile off Point Richmond, jumping clear, slapping the water with their tails with cannon-like report, and cruising along the surface with their dorsal fins high. On November 16, 1941, we watched part of a school of killers playing off Browns Point, sending up towering splashes which were clearly visible at a distance of 3 or 4 miles. Similar play here 4 years later led to reports of a plane accident and futile rescue operations by Army crash boats.

Conflict between killers was reported by only one observer, George Rodgers, who stated that "they fight each other, coming nose together and shooting straight up out of the water." We are uncertain what this behavior represents, and it may, in fact, be fighting.

Reproduction.—The difficulty of distinguishing courtship and copulation from other surface play makes the appraisal of many eyewitness accounts difficult. The following, however, seems to indicate that mating occurs at various points in the inland waters of the state in spring and summer, say April to July.

San Juan Islands, summer of 1939.—C. F. Troxell, commercial fisherman in the San Juan Islands and Rosario Strait, saw killer whales jumping out of the water together, supposedly in copulation. From a point of view about 1,000 feet away, they were estimated to be 25 feet long. Several pairs were in the air at one time.

San Juan Islands, June, 1941.—Vern Ekdahl, Bellingham sportsman, saw killers mating in Rosario Strait between Point Lawrence and Lummi Island. First the females came to the surface, then the males "gave a heave right on top of them."

Point Roberts, about July 1, 1938.—Carl Julius and Richard Peltier, fishermen, saw killer whales "stuck together" on the surface near the big reef southeast of the Point. At this season, killers are always abundant here.

Tacoma Narrows, spring of 1942.—Harold Kimball and Ralph Quistorff, operators of the ferry between Point Fosdick and Titlow, stated that killers were seen mating near the ferry on a sunny day in March or April. The school included 12 or 15 animals. Repeatedly during the day a pair, or pairs, rose to the surface, lay on their sides with ventral surfaces in contact, thrashed the surface, separated, and dived. One animal (the female?) usually rose to the surface and rolled over on its side; a second whale rose and contacted it, and the two lay quietly for a time, then suddenly threshed on the surface and dived.

C. F. Watson, maintenance man at Point Fosdick, placed the time of this display at roughly 3 months earlier (that is, late March or early April), and the numbers involved at 6 or 7 pairs. He also recalled seeing, at various times, pairs of killer whales shoot up into the air together, to fall back tail first into the waters around Point Fosdick.

No pregnancies or births are on record for Washington killers, so far as we know. From the evidence of young specimens (pp. 277-278) we surmise that parturition, like copulation, occurs throughout the spring and summer, and that the young probably remain in attendance for a year or more, or until nearly grown.

The calves of most species of whales swim close to the mother until they are able to feed independently. Otto Boldt stated, however, that at the mouth of Wollochet Bay in the spring of 1932 (?) he saw about 20 young killers, estimated at 4 or 5 feet in length, near shore, while a school of adults swam farther out. Later, the adults joined the young and all swam off together.

Clifford N. Pearson, of Warren, has many times seen schools of killers in Hale's Passage. On one occasion he saw what he interpreted as nursing. While a school of killers played around the Fox Island sandspit he saw one individual, flanked by two smaller ones, lying motionless apart from the school. At length the three dived and the school moved away. The possibility of occasional twinning is indicated here.

Food habits.—The food habits of the killer whale have repeatedly been observed by seafarers from the Arctic to the Antarctic. In the waters of Washington, killer whales are said to eat a variety of foods, including four main kinds: sea mammals, sea birds, fishes, and cephalopods (squid and octopus). Our information on the preyed-upon species is as follows:

Whales.—The killer is famed for its ability to overcome, by wolf-pack tactics, the whalebone whales. Scammon (1874) believed that killers prefer to attack the smaller individuals, as, for example, nursing calves. He mentioned humpback, finback, and gray whales as prey in this connection and these are probably the species most often attacked along the Washington Coast. Wounded adults are reputedly very susceptible to attack. Three members of the Quillayute tribe of the Olympic Peninsula (Joe Pullen, Fred and Morton Penn) told us that the "whale-killer" (*ka-kow-wud*) is common off Hoh Head. The killer rams the whale's belly and, to escape him, the whale leaps out of the water and lands on his own back.

Dolphins.—They are doubtless taken by killer whales in Washington, although of this we have no direct proof. We shall mention under the next topic the behavior of a group of harbor porpoises in the presence of killers.

Seals and sea otter.—We recently published (1944) an account of an attack by killer whales on the harbor seal:

"William Luhr . . . was hunting seals from a boat at the mouth of the Nisqually River and had succeeded in wounding two old males when he suddenly realized that a school of 'thrasher whales' was close at hand. The whales were coming from the direction of open water [Anderson Island], probably in pursuit of harbor porpoises. The whales were from 30-40 feet long, some with a dorsal fin 2-3 feet long and others with a dorsal fin 6-7 feet long, with a shining, white, sickle-shaped mark 2-3 feet long on the side of the body behind the head. As the whales moved rapidly they pushed up a bulge of water 3 feet high in front of them. Several times a whale rose almost under

the boat but did not strike it. The whales attacked at least three seals that were swimming in the mouth of the river, including the two that Luhr had wounded. Their method was to rise from below and strike the seal with the top of the head or snout, roll past and strike the seal a tremendous blow with the tail, knocking off chunks of fat and flesh as large as a man's two fists. The seals appeared to be helpless from fright or were stunned by blows and were easy victims. Luhr rowed toward each of the three victims but was too late to salvage the bodies. He saw them disappear but could not state positively that they were seized finally by the whales. After the whales left, he saw a school of small 'harbor porpoises' leave the river mouth for the open water, and believes that these had been taking refuge while the whales were about. (We have often seen *Phocoena vomerina* in the neighborhood of Anderson Island.)"

A story has come to us by a roundabout way that a tugboat captain, Harry Hicks, of Everett, watched a school of killer whales smash into a log boom in Port Gamble where harbor seals were resting. The seals deserted the logs and headed for the beach, but the whales killed so many of them that the water was fouled with blood and pieces of flesh over a large area.

Scheffer (1940, p. 383) reported that Bob Samson, an old Quillayute, "once watched a blackfish toying with a hair seal, biting and tossing it." Erling Bergerson, Tacoma sportsman and fishing guide, saw a harbor seal seized by a killer at Point Defiance. The seal gave a terrified scream before being carried under. Carl Julius and Richard Peltier, fishermen of Point Roberts, recalled a large seal that once drifted ashore in a badly chewed condition, presumably the victim of a killer.

Although the sea otter has now disappeared from the Washington coast, it figured at one time in the diet of the killer whale. Bob Samson told us that sea otters were afraid of the killers and would move inshore at the approach of a school.

Sea birds.—It is unlikely that sea birds are important in the killer's diet. Taverner (1943, p. 347) writes of a wounded black brant [*Branta nigricans*] which was seized and carried under by killers in the waters east of Vancouver Island. Oddly, the bird was soon released, bobbing to the surface alive, but mutilated and dying. In Commencement Bay on November 16, 1941, we saw rafts of greater scaup and red-breasted merganser take flight at the approach of a breaching killer.

Fishes and squids.—J. E. Guberlet found greenling [Hexagrammidae], ling cod [*Ophiodon elongatus*], salmon [*Oncorhynchus*], and squid [Cephalopoda: Decapoda] (p. 275). Puget Sound fishermen are eloquent in describing the disastrous effects on salmon fishing of the sudden appearance of killer whales. The fish are said to seek concealment in deep water or in the shallows near shore, or to enter the mouth of a nearby stream; and to refuse bait for some time after their fright. On the other hand, salmon are said to ignore the approach of seals and porpoises. C. F. Watson reported seeing salmon lying quietly in shallow water at Point Fosdick during visits of killer whales.

Erling Bergerson saw seven salmon chased upon the beach at Crab Point, Tacoma, by killers. Four of the fish were picked up by a bystander before they could flop back into the water.

Ed Sierer has a photograph of a large king salmon (*O. tschawytscha*) the posterior third of which is raggedly chopped off and the foreparts punctured by teeth, obviously those of a killer. The fish was picked up still bleeding, in shallow water off McKay Beach, near Tulalip, in mid-August. Fishermen found the floating carcass at dawn after the passage of a school of killers.

According to Sierer, killer whales appear in Tulalip Bay only about three times in winter, but every nine days in summer. Their arrival disturbs the salmon fishing for three days. They travel in schools of 12 to 66 and are wary of power boats but come in boldly among pulling boats. On the fishing grounds they work in small groups like platoons, driving along the bar and "hitting every good hole" as they go. Finally they come abreast and swim out, those in the center of the line seeming to lag while the flank animals work the prey into a horseshoe, then into a circle which is gradually narrowed as the killers take turns feeding. The fishing for king salmon is poor for three days after the visit, while the fishing for silver salmon recovers more quickly. Dog salmon are affected least of all. Gill netters in the river get excellent catches of salmon on the next flood tide after the visit of killer whales.

Pink (humpback) salmon are said by Bradner (1944) to be little affected, "as the blackfish will roll right through a big concentration of pink salmon without frightening that species. Commercial fishermen make about the same catch of humpies before, during, and after an appearance of killer whales." We have heard no opinion as to the reaction of sockeye salmon to killers. Our personal observations in late fall at Point Defiance indicate that visits of killer schools to the fishing grounds have only a local and temporary effect on the feeding of "blackmouth" salmon (immature *Oncorhynchus tschawytscha*) and "salmon trout" (*O. kisutch*). Good catches are made in waters adjacent to those where killers are feeding and, several hours after the departure of the killers, good catches are made in their wake.

Fishermen at Point Roberts, Deception Pass, Tacoma, and other places have expressed the belief that killer whales pursue and eat herring. While this is not unlikely, we have little direct evidence to prove or disprove the point. Thousands of herring crowded the shore at Crab Point, Tacoma, on December 15, 1945, during inshore drives of a school of killers, according to fishermen returning to the boathouse.

Killer whale damage to nets and small boats.—In general, killers seem to avoid stationary fishing gear, although two young killers, lengths 7 and 13 feet, are known to have drowned in set nets. Another "over 12 feet long" was shot in a salmon trap. Three reports of nets damaged in the lower Columbia River by "two 30-foot whales" and a 35-foot "sperm whale" may have been founded on killer activities (pp. 282 and 306). George Rodgers, tug captain at Deception Pass, says that killers do not ordinarily strike nets, but that one

went through an old gill net there. C. P. Troxell reported that his nets set for salmon in San Juan Channel in July were entered but not harmed by killers.

Killers seem not to be a serious threat to small craft in Washington waters, perhaps because the average helmsman respects and avoids the animals. In the few instances where boats have been rammed by killers we surmise that the whales had been angered by gunfire or had struck by accident.

Economic status.—The overall effect of the killer whale on the Washington fishery is in doubt. Many fishermen consider it an important predator of salmon and herring while others defend it as a natural enemy of other fish-eaters, including harbor seal, sea lion, diving birds, and predacious fishes. Its infrequent destruction of gear and nuisance to small craft are minor factors to be weighed. More important is its relationship to the future of the rare California gray whale and other baleen whales on this coast.

Although the killer is not at present hunted by commercial whalers, the time may come when its flesh will prove a welcome commodity and its products, such as oil, meal, hormones, vitamins, and ivory, will be utilized. From a recreational point of view many tourists, sportsmen, and naturalists would willingly concede to the killer whale its daily quota of fish, in return for the privilege of seeing a band of killers plunging along through the Sound. Trophy hunters, armed with gun or camera, have a worthy quarry in this handsome and spectacular animal. The case for and against the killer whale is far from complete, and sentence should not be passed until more of the truth is known.

PSEUDORCA CRASSIDENS (Owen) 1846—False Killer Whale

Skeletal remains found near La Paz, Lower California, in 1888, have represented the only record of *Pseudorca* on the Pacific Coast of North America (Miller, 1920). Of more than ordinary interest, then, is an account, in the "Sunday Olympian" of May 16, 1937, of the capture of a false killer whale at the southern end of Puget Sound. The animal was identified at the time as a "blackfish" [killer whale]. We talked with the late Joe Orvis, who assisted in the capture and subsequently preserved the skull, and with other men who were acquainted with the story.

It seems that the whale moved up the ship channel between East Bay Drive and Springer's Mill, ahead of a log raft, on May 15. It was probably in poor health since later examination of the body showed old rifle and shotgun wounds on its back. At low tide, the animal was unable to return to the Sound, although it had a channel 20 feet deep and several hundred yards long in which to maneuver. Joe Orvis, Dick Lenten, and two other men took a small power boat, a .30 caliber rifle, and a light harpoon with 300 feet of line, and pursued the whale. After a chase of two hours in which they had great difficulty in approaching the animal, it stranded on a mud bank and they were able to shoot it through the brain. Officers of the state police had been shooting at it with revolvers from shore to no avail.

Fig. 22.—False killer whale shot at Olympia on May 15, 1937. (J. W. McKnight photo). (See p. 287).

The carcass was lifted on a crane at H. A. Long's boathouse and was photographed (Fig. 22). It was then placed on a truck and carried to a coal scales where its net weight was found to be 1,990 pounds [902 kg]. The total length [probably not standard] was said to be 17 feet, 2 inches; maximum girth 6 feet, 10 inches; thickness of blubber about 3 inches; color, black. The stomach contained "a solid gallon of pin worms" plus a few "salmon vertebrae and ribs." In the opinion of observers, the whale was in poor shape.

Mr. Orvis saved the skull of the whale as a trophy and gave us a few teeth on May 12, 1942 (USNM 270986; original VBS 1278, sex?). From the Orvis estate we later obtained the skull and more of the teeth (JWS 1205). The latter, along with the skull, are now in the Washington State Museum (12515).

The occurrence of a false killer whale at the tip of southern Puget Sound, about 200 miles by water from the seacoast, is remarkable considering that *Pseudorca* is a gregarious, pelagic form that has not previously been recorded in the northeast Pacific. By whatever means the Olympia specimen may have arrived, it is easily understood that, once within the labyrinth of Puget Sound, it might remain indefinitely.

GLOBICEPHALA SCAMMONII (Cope) 1869—Blackfish, Pilot Whale

The stale carcass of a blackfish was found stranded on the ocean beach at Queets, Jefferson County, about September 1, 1937. Although no part of the animal was saved, Mrs. Sidney W. Hubble obtained photographs that serve for identification (Figs. 23-24). We estimate the length of the body at 10-12 feet; sex not apparent.

Animals identified in life as blackfish have been reported by a number of observers along the west coast of North America (Dall, 1869, [North Pacific and Bering Sea]; Osgood, 1901, p. 25 [Queen Charlotte Islands]; Nidever, 1921 [near Santa Catalina Island]; Wailes and Newcombe, 1929, p. 5 [British Columbia waters]. Two specimens from this coast have been preserved: the type, from Lower California (Scammon, 1874, p. 86), and a formalin specimen on display at the Crescent City Aquarium, California, in 1946. A third blackfish was killed at San Pedro, California, on December 21, 1943, but was not preserved. It was identified by Frances N. Clark, supervisor of the state fisheries laboratory at San Pedro.

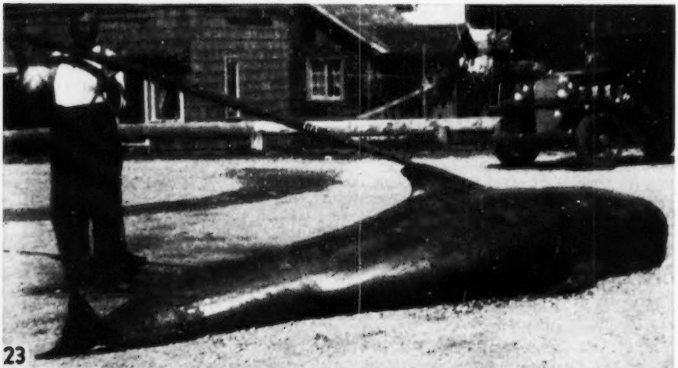
A Quillayute native, Morton Penn, to whom we showed a picture of a blackfish, called the animal *pat-so-ol-ay-qual* or "mole whale." The first three syllables, he said, represent the name of the common black mole [*Scapanus*].

PHOCOENA VOMERINA (Gill) 1865—Harbor Porpoise

Occurrence.—Harbor propoises are doubtless seen more often than any other cetacean in the state. In certain waters along the coast they roll and puff in small groups, every day of the year. We have seen them thus within 30 feet of shore at Steilacoom and far out in Puget Sound. State fisheries official Ed Benn, reports that harbor porpoises are common in summer in the

Strait of Juan de Fuca, and in Dungeness and Port Angeles harbors. In a year and a half at the weather station on Tatoosh Island, David Goheen saw a few porpoises, apparently all *Phocoena*. They are seen in Grays Harbor and Willapa Bay and off the Westport jetty. They are known to ascend the Columbia River as far as the water is brackish (Thwaites, 1904-5, v. 4, p. 163). We have offshore records of specimens obtained on the Swiftsure Bank, 15-20 miles northwest of Cape Flattery, and off the Olympic seacoast as far as 19 miles, while skulls have been dredged from sites 15 to 20 miles offshore in the same region. Specimens have been taken in nets set on the bottom in 40 to 44 fathoms. Harbor porpoises seem to avoid the shallow and muddy waters along the eastern side of Puget and Washington sounds.

In southern Puget Sound the harbor porpoise occurs at all seasons, rarely



23

24

Figs. 23, 24.—Blackfish stranded on the ocean beach near Queets and subsequently hauled to the village, about September 1, 1937. (Mrs. Sidney W. Hubble photos). (See p. 289).

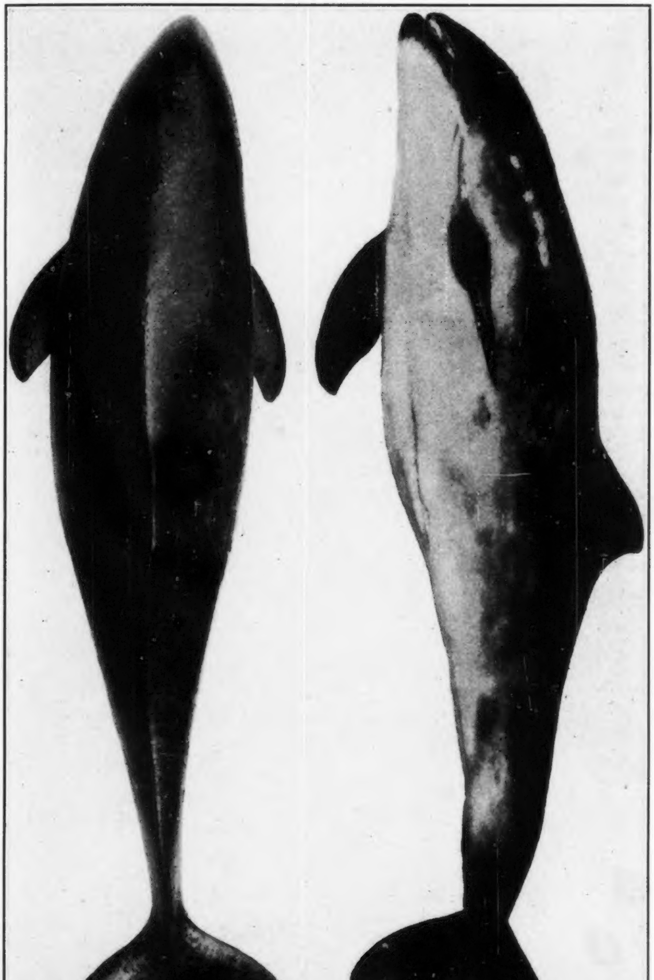


Fig. 25.—Harbor porpoise taken in fish net in Puget Sound in fall of 1941. Specimen VBS 1254, young male, length 1057 mm., weight 34.7 pounds. (See Table 4).

singly, usually in groups of 2 to 5, occasionally 10 to 12 (although it may be questioned whether "rises" or actual individuals are counted when high figures are obtained). Rarely are more than 3 of a group in sight at one time, although several groups may gather in favored waters.

Specimens.—Specimen records of the harbor porpoise are numerous as compared with those of other Washington cetaceans. All Washington-source specimens known to us, totalling 28, are listed in chronological order in Table 4, in which fetal specimens are not listed separately. Measurements in the flesh of 6 adult females are given in Table 5, and lengths and weights of 11 fetal and young in Table 6. We have as yet been unsuccessful in obtaining a specimen of a full grown male.

Color.—The color pattern of the harbor porpoise is indicated in Figs. 25 and 26. The upper parts range from dark gray to nearly black and the under parts from light gray to nearly white. The light color of the under parts extends from almost the margin of the lip to slightly behind the anus. There is always a dark line, split for part of its length, between the corner of the mouth and the flipper.

Two male fetuses (JWS 1206 and 1207) in fresh condition were said by their captors to be "a shade darker" than their mothers. After removal from formalin and superficial drying they appeared as follows: upper parts, flippers, and flukes dark lead-gray; under parts light grayish-olive, shading into darker of upper parts; margin of lower lip bounded by a blackish line extending as a stripe 2-3 mm wide to insertion of flipper; beneath chin finely streaked with longitudinal darker lines; vibrissae light brown (Figs. 29-30).

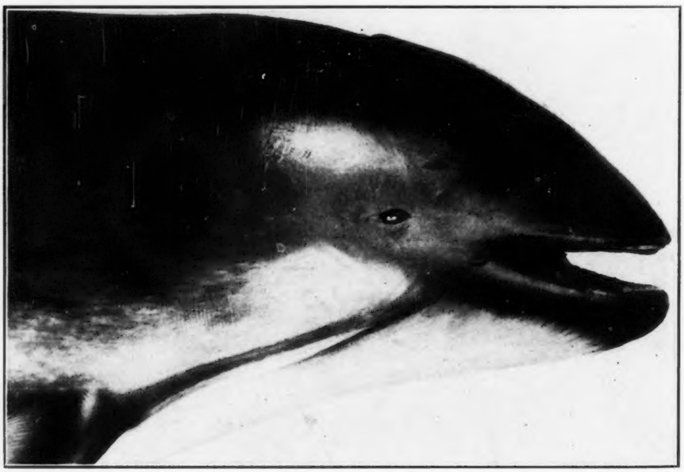


Fig. 26.—Same specimen as in figure 25; detail of head.

A larger fetus (VBS 1270, female), before preservation, was deep olive-brown on the upper parts, including all surfaces of flippers, flukes, and caudal peduncle; under parts, pale olive from lower jaw to insertion of flippers with numerous fine, parallel dusky streaks; clouded irregularly with brown posterior to umbilicus; blending on sides with dorsal coloration; ventral color extending above and around bases of flippers, double line of dusky brown between brown of lower lip and insertion of flippers (Fig. 27).

Vibrissae.—Vestigial hairs near the snout were noted on 4 fetuses and are probably present at some stage of development on all individuals (Fig. 30). They were arranged as follows:

Specimen	*Number of vibrissae on Right side*	*Left side*	*Distance from snout*
VBS 1294	1	1	(not measured)
JWS 1206	3	3	18 to 23.5 mm
JWS 1207	3	2	20 to 26.4 mm
VBS 1270	2	2	23.4 to (?) mm

In a small, suckling female (JWS 1208) a single persistent vibrissa and 3 follicle pits indicated that the placement was 2-2, 27.6 to 33.2 mm. Apparently the vibrissae of the harbor porpoise are shed soon after birth.

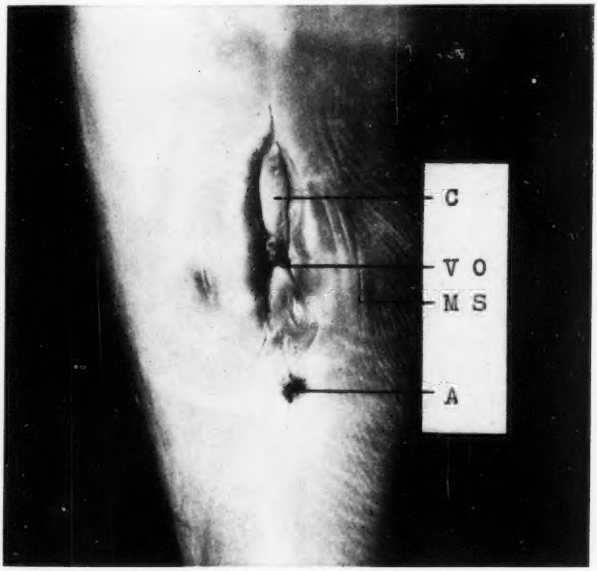
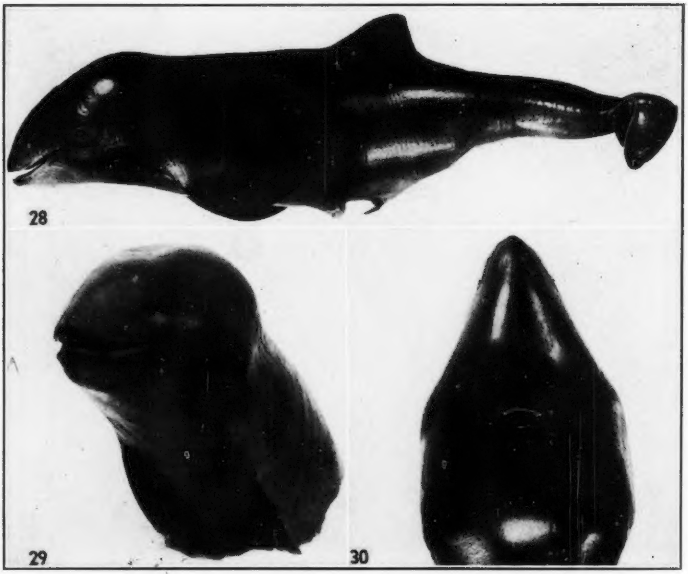


Fig. 27.—Harbor porpoise; external genitalia of female showing clitoris (C), vaginal opening (VO), pair of mammary slits (MS), and anus (A). Specimen VBS 1270, fetus, length 660 mm., weight 7.76 pounds. (See Table 4).

Swimming, breaching, and blowing.—In quiet waters, the roll of the harbor porpoise is leisurely, the first soft "puff" drawing attention to succeeding rises. The "puff" is delivered as a short exhalation followed by a longer inhalation: "huf-uhhhh." There is no splash nor is the spout usually visible. The wet curving backs of a band appear slaty-black to olive-brown or gray, depending on distance, angle, and light. In brisk, uneven succession they breach, loom up, and subside close together, their forward motion visible at a distance by the passage of the triangular dorsal fins up, over, and down (as if mounted on revolving wheels thrust briefly above the surface and withdrawn). As a rule each porpoise rises 3 or 4 times before sounding, although we have counted, with some certainty, as many as 5 rises per individual. The porpoise is exposed for about 2 seconds during the rise and is submerged for a somewhat longer period. We have, to date, detected no difference in the mechanics of the preliminary surface-rolls and the final sounding-roll. The rolls of a porpoise feeding or travelling are separated by a body length or two, and are usually in a straight line, although basking or loafing animals may remain in sight along a course of many yards, or fail altogether to dive, and are prone to wander erratically at the surface. In rough water, or when foraging



Figs. 28-30. Harbor porpoise.—28. Fetus from Olympic seacoast, March 13, 1945. Specimen VBS 1308, male, length 486 mm., weight 3.75 pounds. (See Table 4); 29. Fetus from Henderson Bay, April 22, 1942. Specimen JWS 1206, female, length 480 mm., weight 3.63 pounds. (See Table 4); 30. Same specimen as in figure 29; note blowhole and vibrissae.

for active prey in shallows or dodging boats, the surface actions of harbor porpoises change markedly. They speed up quickly, rise higher in the water when rolling, plunge with a splash, and breathe quickly and violently.

Notes, sketches, and snapshot photographs of typical smooth-water rolls have been taken near Steilacoom on a number of occasions. These represent the roll as lasting about 2 seconds, in the following stages: (1) approach to the surface at a low angle, upper surface of head breaching first; (2) expiration and inspiration as back is exposed from near snout to dorsal fin, body still inclined but levelling off: (3) arching of body and forward roll well underway, dorsal fin ascending; (4) roll continuing, maximum elevation of back attained, strongly arched, dorsal fin beginning descent; (5) arched back line subsiding as dorsal fin nears surface; (6) submergence, with caudal peduncle last seen, flukes not lifted into view. The arched profile line of the snout probably acts as a fender, preventing water from covering the blowhole during inspiration.

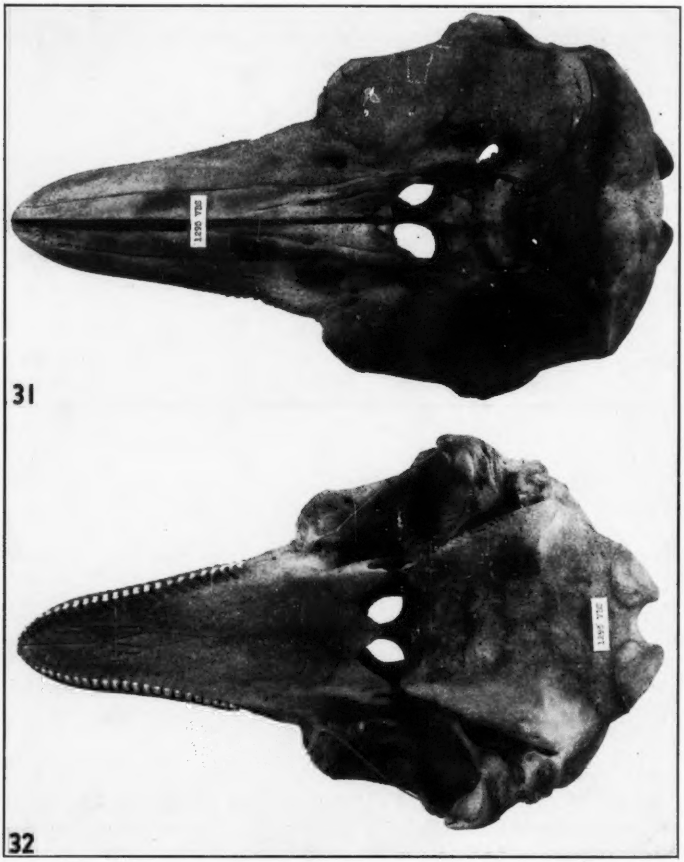
On calm, sunny days porpoises have been seen in the waters of northern Cormorant Passage and off the tip of Ketron Island west of Steilacoom, cruising listlessly near or at the surface as though basking. It is possible, though not likely, that the animals were courting or nursing. A dozen different times on February 27, 1943, single animals or pairs were seen to pause on appearing at the surface and to move slowly with their backs, from dorsal fin to snout, above water for periods of 10 to 15 seconds before they sounded by arching high and rolling. The outline of each, when seen broadside at a distance, was strikingly like that of a surfacing submarine, but the animals moved slowly and changed course frequently, presenting all possible silhouettes. Similar behavior was noted on June 20, 1942, from the Anderson Island ferry, when a porpoise near the tip of Ketron Island slowly played on the surface over an area about 5 yards square, disappearing momentarily several times in half a minute, before rolling out and sounding. Basking was seen from Salter Point on March 31, 1944, a still, warm, sunny day. At least two pairs were seen 5 or 6 times between 4:30 and 6:00 p. m., rolling in the usual way, with a single exception. In one case a pair travelling side by side 200 yards off the Point breached alternately, 4 or 5 times, at points 20 yards apart, moving in the intervals so near the surface that a distinct wake was visible from shore. Progress was steady and unhurried, the trend southward in an irregular line, with long intervals between rises.

In rough, choppy water porpoises in Cormorant Passage began to plunge instead of roll. They rose high and fast, curling over and down with a decided snap and dash. On 2 or 3 occasions a puff of vapor rose for a distance of 3 feet or more and was easily seen as a slim column quickly swept away by the wind. Porpoises off the north end of Ketron Island were plunging so vigorously that, seen from a half-mile away, only the sudden white splashes showed, while the animals remained invisible. Three Quillayute natives told us that when feeding on smelt [?] the harbor porpoise travels very fast and is often near the beach; at other times, it moves in a slow roll.

Phocoena is less playful than other porpoises and dolphins which we have

observed, rarely, if ever, jumping clear of the water and usually ignoring a chance to follow a passing boat. We have not seen the harbor porpoise leap clear of the water nor have we seen it play about a boat, although others have told us of observing these activities. Whether the observations were actually of *Phocoena* is questionable.

Diving.—The depths to which porpoises may descend (in pursuit of food?) are indicated by 6 records of individuals taken in nets set for sharks and bottom fish. Three adults were taken together on a 32 to 44-fathom



Figs. 31, 32. Harbor porpoise. Specimen VBS 1295, female.—31. Dorsal view of skull; 32. Ventral view of skull; maxillary teeth 26 pairs. (See Tables 4 and 5).

bottom (JWS 1206, 1207, and uncatalogued), 2 on a 40-fathom bottom (VBS 1294 and 1380), and 1 on a 4.5-fathom bottom (VBS 1307).

Reproduction.—Harmer (1927, p. 72) states that gestation in the European *Phocoena phocoena* "begins about August and lasts for about 10 months, birth taking place from May to July, the young animals being from 800 to 860 mm . . . in length." Our records of 8 fetuses and 3 young, (Table 6), and the observations of P. G. Putnam, agree with Harmer's statement.

Putnam wrote that in the San Juan Islands "the calf porpoises are from 36 to 40 inches in length during August. Also at this time the males are in breeding condition. From my observations on gillnet-caught specimens I believe that it takes but a year for them to reach approximate maturity. . . . In the months of August and early September the females with their young are taken, but no intermediate sizes seem to be caught" (*in litt.*).

We found a milky substance in the mammary glands of a pregnant porpoise on January 1 (VBS 1293) and noted a considerable amount of thick, yellowish milk in a May 19 specimen (VBS 1270).

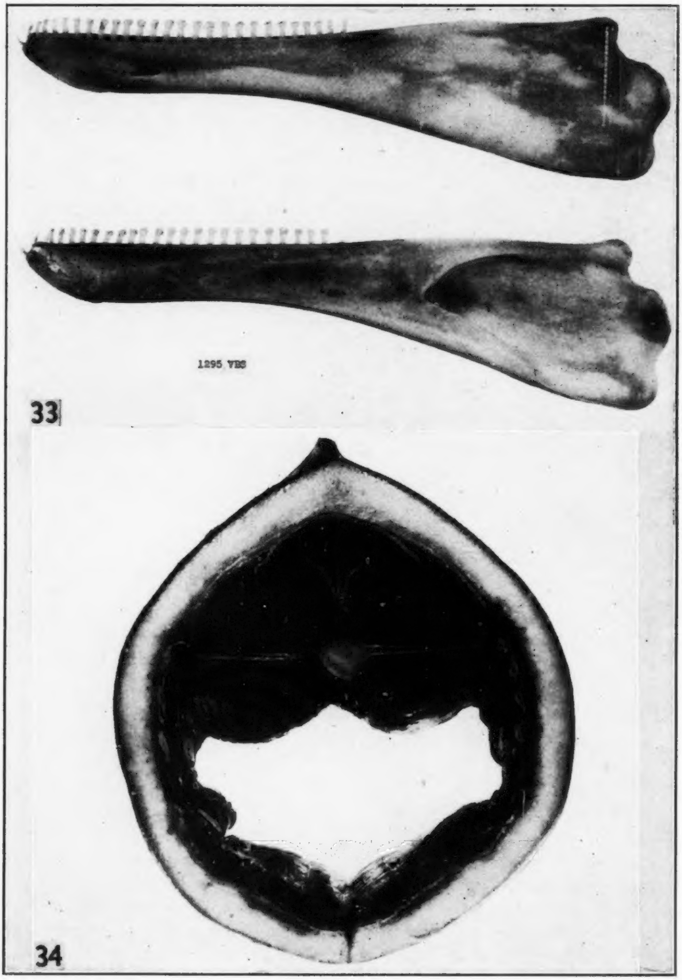
Harbor porpoises are only moderately gregarious. Pairs are seen throughout the year, suggesting that the species is monogamous.

The external genitalia of an unborn female, not greatly different from those of an adult, are shown in Fig. 27.

Enemies.—The enemies of the harbor porpoise in Washington are probably certain sharks, the killer whales, and man. We have no direct evidence of the roles played by the first two beyond the observation that a school of porpoises seemed to show fright during a visit by killer whales (p. 285).

Before the coming of the white man, Indians living along the coast speared or harpooned the harbor porpoise for its flesh (Swan, 1870). Lewis and Clark wrote that "The Porpus is common on this coast and as far up the [Columbia] river as the water is brackish. The Indians sometimes gig them and always eat the flesh of this fish when they can procure it; to me the flavor is disagreeable." (Thwaites, 1904-5, v. 4, p. 163.) Fred Irving says that the harbor porpoise is well known to the Makah under the name of *tseelkh-koo* or *tseelch-ko*. The name also means any small cetacean, as, for example, a dolphin seen too far away to be identified. In former years his tribesmen used to lie quietly in canoes at night, waiting to spear the porpoise as its outline was revealed by luminescence in the water. According to three Quillayutes at Lapush, the local inshore porpoise [certainly *Phocoena*] is *padoozh*. The name has no other meaning. The porpoise is small, brownish-black above and creamy below. The flesh is eaten by natives. The harpooning of harbor porpoises is becoming a lost art among the Olympic natives, the moderns resorting to the shotgun.

The tendency of the harbor porpoise to shun the passing of power boats spares the species, no doubt, from a great deal of persecution by riflemen. A few are wounded each year by duck hunters and "plinkers." One of the Luhr brothers, of Nisqually, shot a porpoise about 4 feet long, weighing 90-100



Figs. 33, 34. Harbor porpoise. Specimen VBS 1295, female (See Tables 4 and 5 and p. 300).—33. Median and lateral faces of mandibles; teeth 26-28 pairs. 34. Transverse section from middle of body near insertion of dorsal fin; viscera removed. Note thin black skin, blubber 20-44 mm. thick, dark muscles, ribs, and long transverse processes of vertebra.

pounds. We have two reports of harbor porpoises being hooked and played on salmon tackle near Tacoma and Bellingham.

Before salmon traps were outlawed in Washington they were responsible for the death of a number of porpoises each year. John Troxell, owner and operator, told of shooting porpoises in his traps in the San Juan Islands, and his son, Conrad, described the animals and stated that they were taken in all traps, but most often in certain ones, especially those stationed in a fast tidal flow. A trap at St. Mary's Point, on Lopez Island, caught 14 porpoises in one summer season of 3 months, about 1929 or 1930. When shot, the porpoises "squealed just like a pig" [through the mouth or the blowhole?].

Fish nets constitute the greatest menace to the harbor porpoise at the present time. In July, 1940, George Rodgers caught 2 large harbor porpoises in a gill net set just outside Deception Pass, and a third inside the Pass. They were found rolled up in the mesh. From fishermen in the neighborhood of Anacortes a professional collector of biological specimens (P. G. Putnam) obtains a half-dozen porpoises a year. These are taken from nets on the salmon ground of McKay Harbor and around Utsillady and Smith Island. In Willapa Bay, "There are many gray porpoises. . . . They run up to 15 or 20 in a school and are of small size, 50-60 pounds. About once or twice a year I get one in my gill net" (Elmer O. Pedersen, *in litt.*). Shark fishermen in Puget Sound occasionally capture porpoises in "diving" nets (set on the bottom) and in tangle and gill nets. We have photographs of 3 specimens taken in *moving* gear, 1 in an otter trawl and 2 in a purse seine. Of the specimens listed in Table 4, 9 were taken in nets of one kind or another. Also, many of the carcasses which are listed as found on the beach dead of unknown cause are probably animals which were netted and later discarded by fishermen.

Parasites.—In the lungs of an adult female (VBS 1293), Ellsworth C. Dougherty found 2 species of nematodes: "*Pharurus convolutus* (Kuhn, 1829) Dougherty, 1943—in a large 'knot' of worms in the medium-sized bronchioles. *Halocercus invaginatus* (Queckett, 1841) Dougherty, 1943—in tiny cysts, about 1-2 mm in diameter scattered in the parenchyma, about 2-6 worms per cyst" (*in litt.*; see also Dougherty, 1943).

P. G. Putnam, collector of natural history specimens, told us of finding nematodes in pockets in the blubber and just under the skin of harbor porpoises taken near Anacortes.

Ascarids of undetermined species were noted in the stomachs of 4 specimens (VBS 1293, 1294, 1307, and 1308); most numerous in the muscular first chamber where also most of the food was found lodged. Crater-like ulcers were found stuffed with knots of these ascarids, their free ends forming tufts. In one stomach, 3 craters were found, 2 in the first chamber and 1 in the second.

Food habits.—Pending the accumulation of many more stomach samples than we now have, and their analysis by specialists, we can offer little information on the food habits of *Phocoena*. In the throat of an adult female (VBS 1270) found dead on the beach north of Grayland, the entire body of a shad

(*Alosa sapidissima*) was lodged so tightly that it quite certainly caused death by strangulation. The shad, 375 mm (14.7 in.) in standard length, had been swallowed head first and lay with its belly against the dorsal wall of the throat. (Orr, in California in 1937, reported a 40-inch harbor porpoise choked by a 22-inch shark.)

In the anteriormost 2 chambers (where most of the food lodges) of 4 adult female *Phocoena* stomachs we found the following items:

Small amount of chyme in second chamber (VBS 1294, netted on a 40-fathom bottom 16 miles SW of Lapush, February 24, 1943).

About 1 liter of fish remains, chyme and fragments accounting for more than half of the volume; the remainder largely vertebral columns and adherent flesh of about 20 slender "herring-like" fish, 12 of the largest ranging from 12-15 cm in length (VBS 1293, found dead on beach at Neah Bay, about January 1, 1943).

A half-liter sample composed two-thirds of chyme and scraps; the remainder of the bodies of moderately slender, non-armored fish, the remains measuring 4.5 to 15 cm long, and up to 3 cm deep (VBS 1307, netted on a 4.5-fathom bottom at Samish Flats, January 20, 1945).

A 1-liter sample composed two-thirds of chyme and scraps; the remainder including vertebral columns 5-10 cm long of at least 7 small, slender, "herring-like" fish; a 19-20 cm sablefish, *Anoplopoma fimbria;* and remains of at least 2 other fish, similar in size and shape and probably of the same species (VBS 1308, netted on a 40-fathom bottom 40 miles W by S of Tatoosh Island, March 13, 1945).

An experienced fisherman of southern Puget Sound told us that harbor porpoises do not disturb or frighten salmon, which continue to feed while the mammals are about.

The favorite foods of the harbor porpoise are probably fishes under a foot in length; of slender form and soft flesh; lacking stiff spines and armor; including types that commonly run in schools near, but not on, the bottom. Such speedy swimmers as the salmon and trout; bottom dwellers; heavily-armed species like the rock-cod and sculpin; and invertebrates with the exception of squid, are probably not important in the diet of the porpoise.

Value of the harbor porpoise.—The flesh of the porpoise was, and still is to a slight extent, used as food by the coastal Indians (p. 297). White men who have sampled the flesh report it variously as excellent to disagreeable. P. G. Putnam has eaten it several times, finding it similar to the flesh of the young harbor seal. He compares it in texture to tender beef, with a slightly wild taste, like venison; the fat is very "fishy."

On February 28, 1943, a female porpoise weighing 122 pounds was captured in a shark net off the Washington coast, iced, and brought to port on March 1. It was then eviscerated and frozen solid. On April 13 it was thawed and sections of the red meat from beneath the back fin were removed (Fig. 34). Samples of the meat were fried and eaten by two persons, one of whom found them palatable. The other reported that "the flesh resembled liver in

texture and somewhat in taste. It was disagreeable, metallic, slightly sour, and with a pasty red substance [blood] around the edges . . . [and] a distinct 'porpoise' odor like that of seal and whale fat." If the carcass were promptly bled and care were taken to keep the muscle meat from contact with the blubber, the former ought to be quite palatable. Freezing may also affect the flavor, as it does that of harbor seal flesh. Various persons have reported that porpoise flesh is accepted by cats, dogs, and pen-raised minks.

A female porpoise weighing 155 pounds was found in fresh condition on the beach January 1, 1943 (VBS 1293). It was held at a temperature slightly above freezing until January 8, when it was frozen solid. On March 9, samples of the flesh were analyzed by the Seattle Technological Laboratory of the Fish and Wildlife Service. Maurice E. Stansby has kindly allowed us to report on the findings (condensed by us), as follows:

	Percentage composition		
	A	*B*	*C*
Moisture	67.6	2.25	67.1
Nitrogen	4.3	0.23	3.58
Protein	27.0	1.45	22.3
Oil	1.24	97.6	3.8
Ash	1.14	0.06	1.67

Lot A: Back muscle, mean of 4 samples
Lot B: Girdle of blubber with skin just ahead of flippers
Lot C: Entire liver

A table giving "characteristics of oils from the Pacific porpoise" [species not stated; described as 5 feet long and weighing 145 pounds] is presented by Brocklesby (1941).

PHOCOENOIDES DALLI (True) 1885—Dall Porpoise

We have obtained no part of a Dall porpoise from the state of Washington.

Two snapshot photographs of a Dall porpoise plunging at the bow of the purse seiner EMBLEM on the Swiftsure Bank off Cape Flattery were taken by Frank Puz in August, 1935. One of the photographs shows the outline and conspicuous white flanks, leaving no doubt as to the identity of the animal. Mr. Puz told us that this kind of porpoise commonly plays around boats on the Swiftsure Bank.

C. T. Larsen says that a Dall porpoise was harpooned from the motorship CATALYST in the Strait of Juan de Fuca, between Sauk Inlet and Port Angeles, in the summer of 1937. Kelshaw Bonham took several photographs of the animal (Fig. 36) and it is possible that the specimen is identical with the host listed in the J. E. Guberlet collection of parasites, as follows: "Porpoise ♀ adult. Strait Juan de Fuca, July 3, 1937. J. E. G. No. 1209. Examined by [Ashton C.] Cuckler and [Robert H.] Shuler, Univ. of Nebraska. Nematodes 5: 1—intestine, alive; 4—stomach, alive. Stomach contents, eyes, i. e., lenses, — fish and squid beaks."

We have a number of undated photographs of Dall porpoises brought into the Oceanographic Laboratories at Friday Harbor in 1936 and 1937. Some of the porpoises were said to have been harpooned from the CATALYST and others to have been brought in by commercial fishermen landing at Friday Harbor (Fig. 35).

One December 20, 1941, at 9:40 a. m. we watched a number of Dall por-

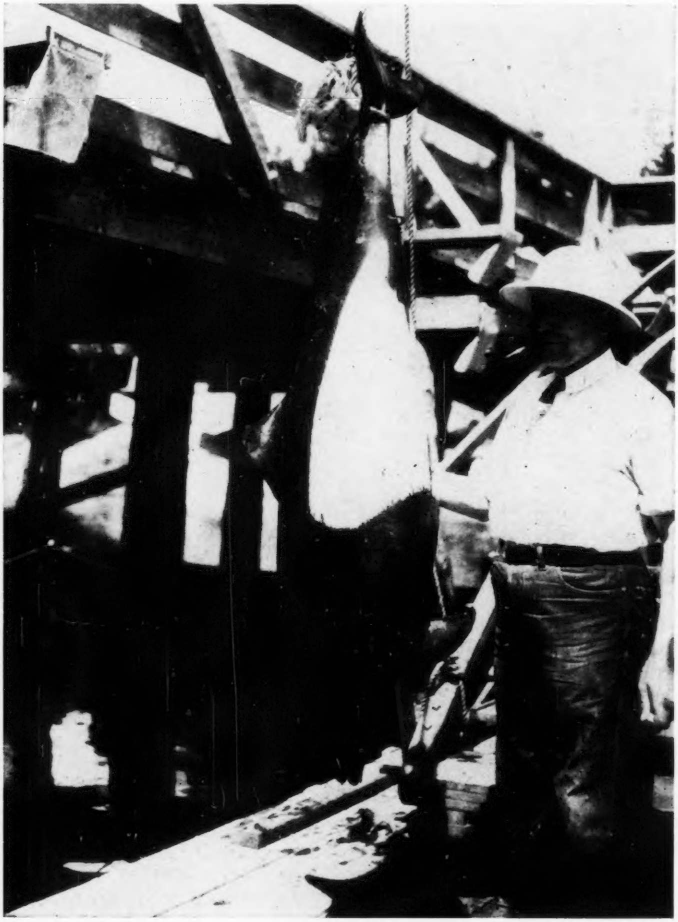


Fig. 35.—Dall porpoise; source uncertain and specimen not saved; Friday Harbor, July or early August, 1936. (George W. Martin photo). (See p. 302).

poises playing at the bow of the motor schooner BLACK DOUGLAS, 19 miles west of Copalis (Scheffer, 1942).

Two Dall porpoises of unknown source, possibly Alaska, were hanging in the Frozen Fish Exhibit of the Port of Seattle, Pier 24, on February 13, 1942.

Quillayute natives Joe Pullen, Fred Penn, and Morton Penn described to us the Dall porpoise as: "*klak-oo-dakh;* means broken tail; the tail is bent sharply when diving; the body is bent one-third the distance from the tail to the head; it is real black on the back and white on the belly; it is a deepwater porpoise."

A Makah, Fred Irving, described *Phocoenoides* as follows: "*kw-kwacht-kle* is the largest of the three common porpoises [*Lagenorhynchus* or *Delphinus?*, *Phocoena*, and *Phocoenoides*] and the name means broken tail; the back is black, the tip of the dorsal fin is white, and the belly is white; a 'hunch' on the back is conspicuous when the porpoise breaks water; it lives at sea, rarely coming into Tatoosh Island. The flesh is good to eat and tastes like liver."

DELPHINAPTERIDAE, ARCTIC DOLPHINS

DELPHINAPTERUS LEUCAS (Pallas) 1776— White Whale, Beluga

On May 13, 1940, Cecil Brosseau, employed at the Point Defiance Aquarium, Tacoma, told of seeing "about a month ago" a pure white animal with horizontal tail fin. Wilhelm Jordan, manager of the aquarium, who was with Brosseau at the time, wrote a description of the animal and sent it to Phil Nelson, student at the University of Washington, who identified it from Norman and Fraser (1938) as a beluga. On June 26 Mr. Jordan gave us the following story:

"The whale was sighted by fishermen on the dock in front of the Point

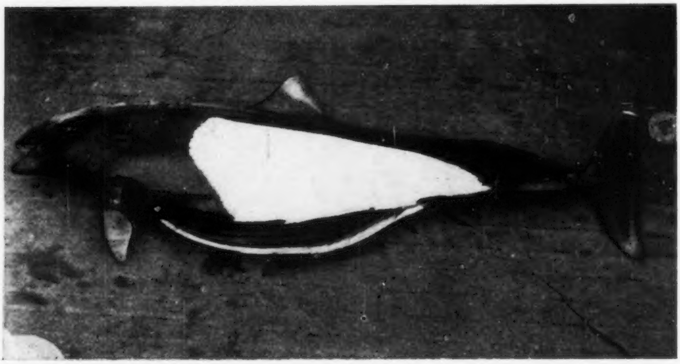


Fig. 36.—Dall porpoise aboard motorship CATALYST at Friday Harbor; said to have been harpooned between Sauk Inlet and Port Angeles in the summer of 1937. (Kelshaw Bonham photo). (See p. 301).

Defiance pavilion on, or about, April 20. It blew at a distance of 60 feet from shore. Jordan, Brosseau, and others gave chase in a launch, following the whale closely at 5 or 6 knots for a mile or more along shore. It swam in about 10 feet of water, occasionally scraping bottom; when past Crab Point it dived directly under the launch, showing a horizontal tail 3 or 4 feet wide. It was 15 to 18 feet long, grayish-white, and without a dorsal fin. It was reported seen at Day Island 2 or 3 days later."

The "Tacoma Times" for April 23, 1940, carried a news item which described, in rather fanciful terms, the appearance of this whale south of the Narrows on the morning of April 23.

On June 21, 1942, T. D. Van Slyke of Steilacoom said that about three years previously, in the fall, a small white whale was seen several times off Steilacoom. Perhaps the Point Defiance whale stayed south of the Narrows for several months after it first appeared.

We are inclined to believe that the whale described by Jordan and Brosseau was a white whale or beluga, far removed from its native haunts. To the best of our knowledge, the species has not previously been seen south of Cook Inlet, Alaska, about 1,500 miles northwest of the state of Washington (Osgood, 1904, p. 27). On the Atlantic coast, however, white whales have appeared as far south as Massachusetts, near latitude 42° (Townsend, 1929).

Family PHYSETERIDAE, SPERM WHALES

PHYSETER CATODON Linnaeus 1758—Sperm Whale

Sperm whales were taken commercially along the Washington coast during the days when the Bay City station was in operation (Figs. 39-40). Over a 15-

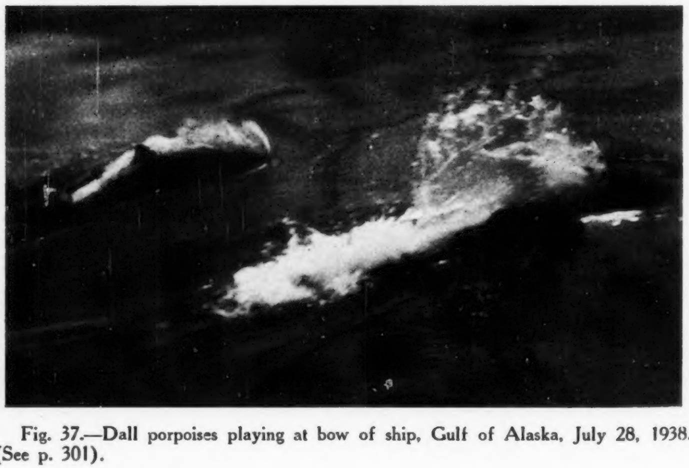


Fig. 37.—Dall porpoises playing at bow of ship, Gulf of Alaska, July 28, 1938. (See p. 301).

year period, 120 sperm whales were landed at the station, the catch varying from none in 1912, 1921 and 1925, to nineteen in 1919 (Table 1). In the last year, 6 sperms were taken by 3 ships in 1 day. "Pacific Fisherman" reports that 3 sperms were brought in by 1 ship as a day's catch in the summer of 1916 (v. 14, p. 34). The whaling season covered the months of April to October, and sperm whales were recorded taken in all months but April and September.

Certain products of the sperm whale—sperm oil, spermaceti, wax, ivory, and ambergris—afford another index of the importance of this species (Table

Fig. 38.—Dall porpoise playing at bow of ship, Gulf of Alaska, July 28, 1938. (See p. 301).

3). According to William Schupp, a lump of ambergris was taken in 1911 which weighed 350 to 400 pounds and was sold for $43,000. A certain amount of the ivory listed by Radcliffe as collected on the west coast in 1918, 1919, 1920, and 1922 likely came from the Washington station (1933, p. 33).

According to Victor H. Street, who supervised the construction of the Bay City station and remained in charge in 1912, the stomachs of sperms usually contained octopus and squid beaks, often a "bushel basket-full." No seals or porpoises were found. Street recalled seeing 1 "flatfish" in a stomach (*cf.* Robbins *et al.*, 1937, pp. 19-20; *Acrotus willoughbyi* in stomachs of sperm whales taken off British Columbia).

Certain bones of a sperm whale, mixed with those of other species of whales, were noted on the premises of Fritz Menath at Copalis, in 1942. According to Gordon Alcorn, the sperm whale bones were taken from a large individual that was stranded, dead but still warm, at Oyhut in May, 1938.

Another sperm whale was stranded 2 miles north of Ocean Park on May 10, 1943 ("Chinook Observer," Long Beach, Washington, May 14, 1943, p. 1). On May 29 we examined the partially buried and mutilated carcass, obtaining the following data: Male, total length 49 feet 6 inches, standard length 47 feet 10 inches, depth of tail notch 20 inches, breadth of tail 13 feet 4 inches, axial length of flipper 4 feet 2 inches, breadth of flipper (at axilla) 2 feet 2 inches, length of head to center of occipital hump 14 feet 8 inches, depth of snout at line of blowhole, about 7 feet, center of anus to center of preputial opening 3 feet 10 inches, length of dorsal fin-like protuberance 3 feet 9 inches and height 9.5 inches, chord of blowhole 19 inches. The lower jaw, penis, and otic bones had been removed or destroyed. The lower jaw, however, had previously been measured by Matt Saarela and George Esveldt at 9 feet.

A report of a 35-foot "sperm whale" drowned in a fish net in the Columbia

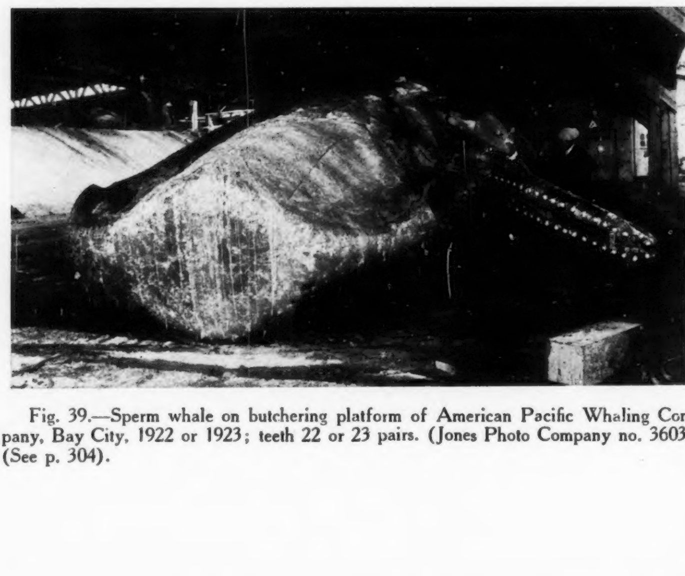


Fig. 39.—Sperm whale on butchering platform of American Pacific Whaling Company, Bay City, 1922 or 1923; teeth 22 or 23 pairs. (Jones Photo Company no. 3603). (See p. 304).

River below Tongue Point, Oregon, March 13, 1939, has not been verified (International News Service, Astoria, March 14, 1939).

KOGIA BREVICEPS (Blainville) 1838—Pygmy Sperm Whale

The genus *Kogia* is represented by a single species. Probably 50-60 specimens, many fragmental in nature, have come to light in the century following the discovery of the type. Although it is widely distributed in the temperate seas of the world, only one specimen has been found on the Pacific coast of North America, a fragment of a lower jaw from Mazatlan, Sinaloa, Mexico, the type of "*Kogia floweri*" Gill, 1871. A specimen found recently in Washington is thus of considerable interest.

The Washington specimen was seen on the beach by Howard Harris on May 16, 1942, at a point 2 miles south of Grayland and was recovered by us on May 19 with the help of Harris and Dr. Kelshaw Bonham (USNM 270979; original VBS 1269, male, skull and skeleton). It was then judged to have been dead for at least 2 weeks (Figs. 41-42).

It bore several axe cuts and the skin was eroded over large areas, but not enough to entirely obscure the color. Weight 242 pounds (109.7 kg); snout

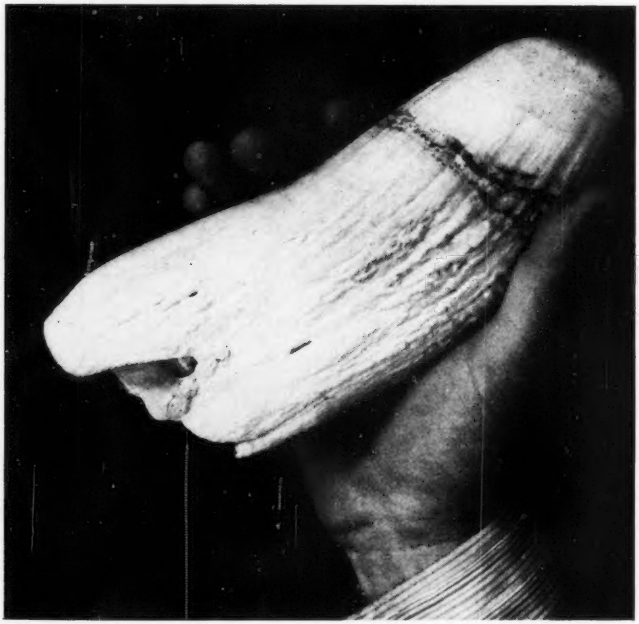


Fig. 40.—Sperm whale tooth from Bay City whaling station. (See p. 304).

to base of tail notch 1885; girth behind flippers 1055; girth of head 30 mm behind corner (gape) of mouth 934; greatest width of head (10 mm ahead of eye) 317; width and height of body at posterior edge of flipper bases 360 and 349; greatest width of tail flukes 531; between tips of flukes 511, depth of tail notch 34; circumference of caudal peduncle at insertion of flukes 310; width and height of peduncle at insertion of flukes 59 and 152; axial length of right flipper 257; curvilinear length of forward edge of right flipper 295; greatest width of right flipper 105; height of dorsal fin 93; axial length of dorsal fin (tip to midpoint of insertion) 150; curvilinear length of forward edge of dorsal fin 260; center of anus to base of tail notch 582; center of anus to center of urethral opening 218; center of anus to tip of snout 1353; length of lower jaw (middle of lower lip tc corner of mouth) 110; projection of teeth anteriorly beyond lower lip 4; tip of snout to tip of lower lip 157; between corners of mouth 64; between insertions of flippers 196; tip of snout to midpoint of blowhole slit 228; maximum width of blowhole (not at right angle to long axis of body) 53; from midpoint of blowhole slit to midpoint of a chord connecting ends of slit 13; center of eye to center of ear opening 65; length (horizontal) and width (vertical) of ear opening 1 and 0.3; length (horizontal) and width (vertical) of eye opening 25 and 11; length of penis: stretched 380, relaxed 246; diameter of relaxed penis grading evenly from 22 at base to 5 only 1 mm from tip; dimension of left testis 25 by 90. Color, as nearly as shown by this abraded specimen, black above; white below, including bases of flippers.

The stomach contained about 500 cc of nematodes and a few fragments of food, as follows: 11 eye-lenses (unidentified); 5 squid eye-lenses; 15 squid beaks; 21 otoloths of unidentified fish; 1 limb segment of a crab; several bones of small fish or fishes, including maxillaries of at least 2 specimens of *Trichodon* (?); several fragments of shrimp (Carides) identified by Belle A. Stevens as *Pasiphaea pacifica* Rathbun, *Pandalus* (*borealis* Kröyer?), and *Pandalopsis* (*dispar* Rathbun?). The nematodes recovered from the throat and stomach and 3 or 4 tapeworm cysts found embedded in the perianal flesh are as yet unidentified.

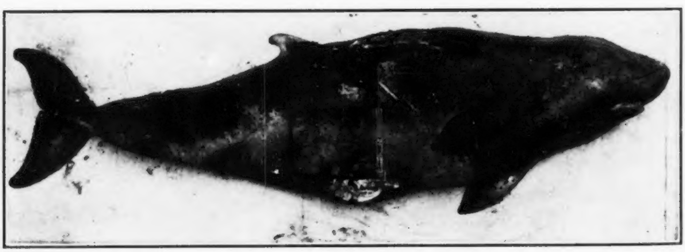


Fig. 41.—Pygmy sperm whale stranded at Grayland; photographed May 19, 1942. The body was found in mutilated condition; note axe cut on snout and slit on belly with penis protruding. Specimen VBS 1269 (See p. 307).

That at least one other pygmy sperm whale has been stranded on the Washington coast is indicated by the statement of Lance Kalappa, elderly Makah native, who told us through an interpreter that many years ago a porpoise or small whale remarkable for having an inferior mouth "like a dogfish" [*Squalus*] washed ashore on the beach south of Cape Flattery.

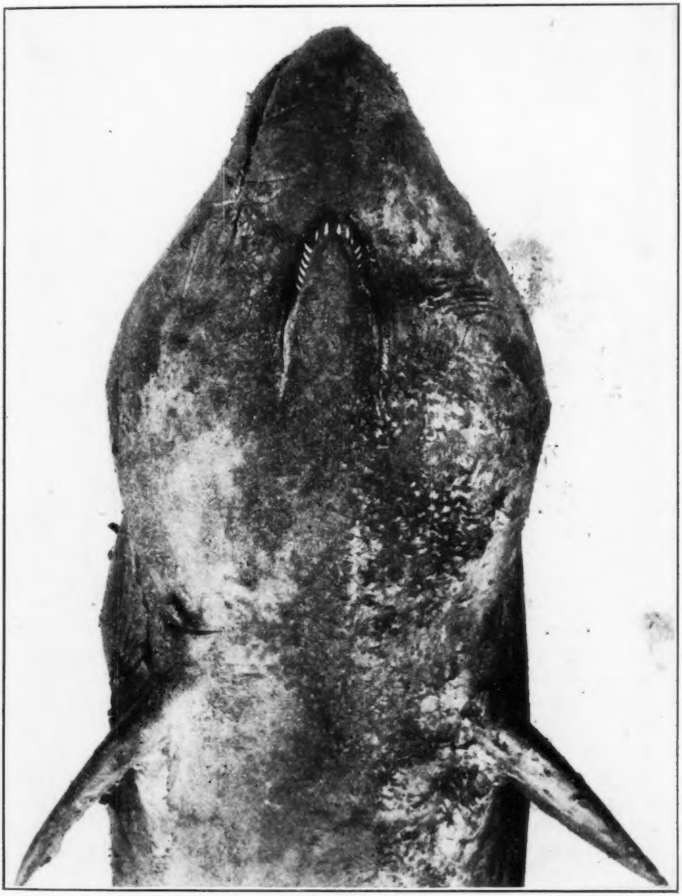


Fig. 42.—Same specimen as in figure 41; under surface showing small jaw and weak, divergent teeth.

Suborder Mysticeti, Whalebone Whales

Family RHACHIANECTIDAE, GRAY WHALE

RHACHIANECTES GLAUCUS (Cope) 1868—Gray Whale

The gray whale of the North Pacific, a "living fossil" without counterpart elsewhere in the world, was the first of the Washington whales to be threatened with extinction. As an inshore species of small size and moderate speed, the gray whale was long the prize of Indian whalers on the Olympic seacoast, where it was taken chiefly on its northward run in the spring (Figs. 2 and 3). Thousands passed twice a year along the coast in migration between the breeding lagoons of Lower California and the Arctic Ocean. With the advent of whaling by white men about a century ago, a slaughter began which in a few decades resulted in its commercial extinction. The greatest damage was done by whaling outfits wintering in the California lagoons. Between 1900 and 1924, or thereabouts, shore whaling moved farther north to the coast between northern California and Alaska, and the gray whale was allowed a certain amount of rest on its breeding grounds. In 1924, however, whaling was started anew in Lower California, this time by a floating factory, and the death knell of the gray whale was sounded with the taking of 222 individuals in 5 seasons (140 of them in the first season). The gray whale fishery during this period stands as a notorious example of commercial ruthlessness.

Scammon's early account of the treatment of the gray whale on the northwest coast is worth repeating:

"After evading the civilized whaler and his instruments of destruction, and perhaps while they are suffering from wounds received in their southern haunts, these migratory animals begin their northern journey. The mother, with her young grown to half the size of maturity, but wanting in strength, makes the best of her way along the shores, avoiding the rough sea by passing between or near the rocks and islets that stud the points and capes. But scarcely have the poor creatures quitted their southern homes before they are surprised by the Indians about the Strait of Juan de Fuca, Vancouver and Queen Charlotte's Islands. Like enemies in ambush, these glide in canoes from island, bluff, or bay, rushing upon their prey with whoop and yell, launching their instruments of torture, and like hounds worrying the last lifeblood from their vitals. The capture having been effected, trains of canoes tow the prize to shore in triumph." (1874, p. 29.)

A single specimen of gray whale is recorded in the statistics of the Bay City station. Kellogg (1931, p. 74) listed one taken in 1924, but his figures and those of Radcliffe (1933) for the year 1924 do not quite agree. It is possible that Radcliffe lumped the gray whale with the humpback whales in this, and perhaps other instances. Thus, Victor H. Street, in charge of whaling at Bay City in 1911 and 1912, told us that a few gray whales "very lousy along the jaws" were taken in these years. "Pacific Fisherman" reported that a "California humpback" [gray whale?], taken on March 14, 1912, was the first whale of the season at Bay City (v. 10, p. 24).

Several factors account for the poor take of gray whales by the Bay City whalers. The gray was considered a "scrag" species, poor in fat, and of less value than other whales that were still available in satisfactory numbers. Also, the tendency of the gray whale to move near shore may have kept it out of the path of the killer ships, and its schedule of migration may have brought it past the Bay City station before and after the whaling season. At any rate, very few gray whales were taken anywhere along the coast in the years preceding the slaughter which began in Lower California in the winter of 1924-1925.

As an inshore species the gray whale doubtless appeared at times within Puget Sound, but of this we have no proof. A. M. Akin, then manager of the Point Defiance boathouse, Tacoma, told us that about 1938 a 20-foot whale rose near his fishing boat close to shore just south of the lighthouse at Point Defiance. It was dirty gray, not very fast, and bore barnacles; it blew and disappeared. Akin was particularly impressed by the gray color, not at all like that of the Shelton finback which he had helped to capture and exhibit (p. 312). The Tacoma newspapers were said to have reported the incident. Erling Bergerson, Akin's companion, recalled similar characters except that the color was brown, the barnacles large.

A second whale, supposedly a gray, was seen in March, 1941, by David Goheen from Tatoosh Island. He saw 20 feet or more of the back of a large whale which rose about 200 feet from the island to blow, then moved out to sea. As seen under very favorable circumstances from an elevation, it was a rather light gray color, lacked a dorsal fin, and was heavily encrusted with barnacles.

Family BALAENOPTERIDAE, FURROW-THROATED WHALES

BALAENOPTERA PHYSALUS (Linnaeus) 1758—Finback Whale

The finback, speediest of the large whales, was seldom taken by whalers prior to the advent of the steamship and gun-fired harpoon. It was commonly seen, however, and was occasionally taken by Makah natives off the Olympic coast. Scammon "had but little opportunity to observe the Finbacks that frequently rove about the Gulf of Georgia and Fuca Strait. Several have been seen, however, in May and June, on the coasts of California and Oregon, and in Fuca Strait in June and July of the year 1864; these observations satisfy us that the dorsal fin of this—the northern species referred to—is strikingly larger than in the more southern Finbacks. . . . Those we have noticed about Fuca Strait seem to have the back fin modified in size between the extremely small one found on the coast of Lower California and the one here represented" (1874, p. 36). Scammon may have been confused by glimpses of the sei and piked whales which the whalers of the coast did not ordinarily distinguish from the common finback. Collins reported that the Quillayute tribe also engaged "in whaling during the summer; nine finback whales were captured in 1888; these were cut up and smoked for food. The catch is wholly for home consumption and has no commercial importance" (1892, p. 245).

An excellent account of living finbacks in the waters of British Columbia

and Alaska was given by Andrews (1909). On p. 224 he mentioned the "peculiar depression or groove running longitudinally just beneath the ridge of the back" which he observed on finbacks in the act of breaching, supposed to be "due to the action of the scapular muscles as the whale uses the flippers in descending." Our figure (45) of a finback lodged in a log boom near Shelton shows a groove of this nature.

At the Bay City station, the finback ranked second in numbers to the humpback. Altogether, 602 finbacks were taken (Table 1), although the total may include a few misidentified sei and little piked whales. A seasonal catch record (Table 2) suggests a spring maximum of finbacks in May-June and a fall maximum in September. Few measurements or observations of the finback in Washington are available. "Pacific Fisherman" mentioned a 78- foot finback as the largest whale of the 1912 season (v. 10, p. 30). The absence of finbacks from the spring catch of 1925 after the 68 recorded for the previous year is unexplained.

In August, 1930, a lone finback moved southward toward the head of Puget Sound, entering Skookum Bay at Shelton about 2 a. m. on Friday, the 22nd ("Mason County Journal," Shelton, August 25, 1930). About 9 o'clock in the morning it became entangled in the piling of the Reed cedar mill where it was shot several times with a high-powered rifle and seen by a number of people before it finally escaped. "From the cedar mill Mr. Whale dashed across the bay to the end of the Simpson Logging Company booms, where he managed to again get well stranded. This time he went under the outer boom stick and lodged with logs parallel on each side. Here he remained caught fast for 12 hours [?], during which time hundreds of people walked over the

Fig. 43.—Finback whale; 45-foot female stranded at Kalaloch in October 1941. (Olympic National Park photo no. 448, by Neal Mortiboy). (See p. 316).

logs to view the sea monster. The water was so shallow that the whale couldn't spout at this spot, although the spectators were well sprayed during his visit to the mill." (*op. cit.*) Photographs were taken of the whale in this position (Figs. 45-47). A party from Tacoma, headed by A. M. Akin and including Carl W. Evans, harpooned the whale but did not succeed in killing it. Escaping on the next high tide about 5 p. m. the whale moved into "Oakland Bay" and lodged in a cove or slough on the "Gosser Place," where it died. Extricated with some difficulty on Saturday, it sank, but later rose and was towed

Fig. 44.—Same specimen as in figure 43; note color of whalebone in right anterior half of jaw: anterior plates white, posterior plates darker. (Olympic National Park photo no. 449, by Neal Mortiboy).

Figs. 45-47.—Finback whale; male 55-60 feet in length caught between floating logs at Shelton, August 22, 1930. (Jeffers Studio, Olympia). (See p. 312).

to Tacoma by a Foss tug. On Sunday the carcass was exhibited at Point Defiance park to about 10,000 people who paid 25 cents apiece for the privilege. At 4 in the morning of Tuesday the carcass was towed to Luna Park, Seattle, where health officials refused to let it be shown ("Tacoma Ledger" and "Tacoma Times," August 27, 1930). Under new management, the whale appeared on the beach near Titlow and was eviscerated before Tacoma health officers arrested the men in charge. A plan to embalm the creature was abandoned and, fortunately for the residents of Titlow Beach, the carcass disappeared.

The whale was probably 55-60 feet long, with an exserted penis 5-6 feet long. Carl W. Evans, a commercial fisherman who harpooned this individual as well as certain other Puget Sound whales, said that it was easily the largest ever taken in the Sound, being "some sixty feet in length" with a weight of 35 tons and "built like a race horse." ("Tacoma News-Tribune," August 29, 1930, p. 13). The whale was publicized in the press and in scientific journals (Couch, 1930; Bailey, 1936) as a *humpback*, but on the basis of photographs and other evidence at hand it must be regarded unquestionably as a finback. A small piece of its baleen (saved by Akin) has been identified by Remington Kellogg as that of either a humpback or a finback.

Another large whale, probably a finback, was pursued in Puget Sound in 1915. According to the "Tacoma Times" (August 22, 1930, p. 16): "Ten years ago, Evans, Morse, and Bert Nelson harpooned a whale and had almost landed it when it rolled on the rocks at Point Defiance, breaking their line. That disaster caused by engine trouble allowed the whale to make its escape. It, however, came to grief when it was captured by whalers at Barclay Bay [Vancouver Island]." From C. Forrest Hurd, only surviving member of the whaling party, we obtained a running account of the affair. It seems that the whale appeared in Vaughn Bay, southern Puget Sound, in July or August, 1915. Hurd and two other men went after it in a speed boat. Dozens of rowboats were on the scene, their occupants peppering the whale with rifle fire at each rise. The whale would rise to blow, then submerge for 3 to 5 minutes, his every move betrayed by a wake on the surface. Once, when shot with a heavy caliber rifle, the whale rose in a clean "salmon leap" so high that the speed boat could have passed under it. At last the whale made the entrance to the bay and went south. A week or so later, the whaling party, now 5 in number, intercepted the whale between Point Defiance and Clam Cove (Tahlequah). Equipped with 1,300 feet of $\frac{5}{8}$-inch line in a barrel, two harpoons, and a lance, Evans finally succeeded in jamming the harpoon deep into the whale. The line snatched off part of the line-tender's coat and the whale towed the party in a big circle for an hour and a quarter at a rate of 6-7 miles an hour, starting toward Brown's Point and ending near Crab Point. There the whale reached shallow water and seemed to be rubbing its back on the rocks, as from a distance of 200 feet the light color of the belly could be seen through the water. The line then parted from the eye of the harpoon and the whale started north through West Passage. The chase was abandoned at Bainbridge Island that night. Hurd recalled that the whale was about 65 feet long, with

no unusual proportions and without barnacles such as characterize the humpback; dark above and light below. It usually stayed down 3 to 5 minutes, showed twice, and spouted to a height of 20 feet.

On October 6 or 7, 1941, a 45-foot female finback washed ashore on the Olympic coast at Kalaloch (Figs. 43-44). Wilbert M. Chapman and Donald Shipley visited the carcass on October 10 and measured it in inches, as follows: snout to base of tail notch 544; maximum depth of body 110; maxi-

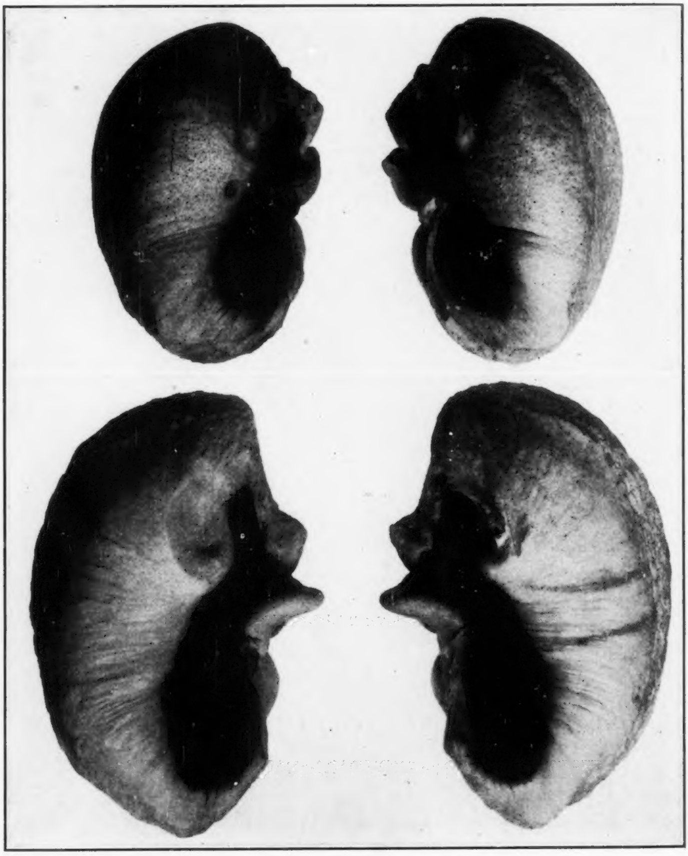


Fig. 48.—Tympanic bullae or "ear bones" of two species of whales: finback (larger pair) and humpback (smaller pair); dorsal view, one-half natural size. Saved from Bay City whaling station by Andrew Falkwood.

mum width of one fluke 56; depth of tail notch 5; snout to insertion of flipper 150; length of flipper along anterior edge 57.5; length of flipper along posterior edge 41; maximum width of flipper (near middle) 14.5; upper jaw, snout to eye, 87.5; lower jaw, symphysis to vertical from eye 113; base of tail notch to anus 159; length of eye opening, closed 8 1/3; length of foremost baleen plate 3; length of hindmost baleen plate 18.5. Number of baleen plates on left jaw 288; approximate number of ventral or throat grooves at level of flippers 48. The stomach was empty and the layer of blubber was very thin, not over 1.5 inches on the belly and 1 inch on the back. The under surface of the body, including the tail, was white. Although the dorsal fin was buried in the sand its position was certainly somewhere on the body behind the level of the mammae.

Chapman and Shipley tentatively identified the animal as a blue whale; however, we subsequently obtained a photograph (Fig. 44) which shows the distinctive, variegated baleen of the right jaw of the finback whale.

BALAENOPTERA BOREALIS Lesson 1828—Sei Whale

Our information on this species in Washington is derived from the Bay City whaling records. In 4 of the 13 years of operations, sei whales, totalling 21, were taken (Table 1). From discrepancies in the various records which are available to us, we suspect that 3 species of whales were at times confused by the commercial whalers, namely, the finback, little piked, and sei. The data on Washington sei whales are insufficient to indicate the season of greatest abundance, although all 5 individuals for which we have date records were taken in April and May (Table 2).

BALAENOPTERA ACUTOROSTRATA Lacépède 1804—Little Piked Whale, Sharp-Headed Finner Whale

Information on this smallest of the baleen whales of the Pacific Coast is meager, doubtless because its size makes it commercially unattractive and because it is confused with other species of *Balaenoptera*. The first specimen recorded from Washington was the type of Scammon's *B. davidsoni* (1872, p. 269), a skull (USNM 12177) taken from a 27-foot female found dead on the north shore of Admiralty Inlet by Italian fishermen and subsequently towed to Port Townsend Bay for flensing. Except for the fact that it contained a 5.5-foot well-formed fetus, Scammon would have judged it to be a young finback, in accordance with the belief of Pacific whalemen of that period. Shortly afterward Scammon published an account, as yet to be excelled, of the little piked whale in our local waters. He stated that "they cannot be considered as objects of pursuit by whaling vessels, and are but rarely taken by the natives of Cape Flattery—they being the only whalers in that region who attempt the capture of these animals" (1874, p. 51). Confirmation of this statement was given by Collins, who reported that little piked whales were captured by Indians off Cape Flattery and the Strait of Juan de Fuca (1892,

Fig. 49.—Little piked whale; female captured in a salmon trap in Puget Sound about 1926, frozen, and deposited in a Seattle cold storage room. Light color of specimen is due in part to frost. (Photo from Howard Langrud). (See p. 319).

p. 245), and by Waterman, who listed *B. davidsoni* and *B. velifera* [*physalus*] as the finbacks taken by the Makah (1920, p. 42).

Recent specimens of the little piked whale from the northwest coast are few. None were recorded in the catch records of the Bay City whaling station, although a few of the finback and [or] sei whales reported taken were possibly of this species.

Cowan has recently described 2 specimens from Vancouver Island and has compared them with specimens of the little piked whale from the Atlantic coast. He finds that "existing material is inconclusive. There is a suggestion that Pacific individuals may be found to differ from Atlantic individuals in the slightly more posterior position of the dorsal fin, slightly narrower flukes, and in proportional differences in form of the scapula and sternum. I have been unable to discern any significant cranial differences between the specimens from the two oceans. Pacific individuals may have fewer baleen plates; on the other hand the observed difference may merely be the result of individual or age variation. Should the above differences be substantiated there would be ground for recognizing *Balaenoptera davidsoni* as a subspecies of *B. acutorostrata* Lacépède but in the light of present knowledge taxonomic recognition of a Pacific speices is apparently not justified" (1939, p. 224).

About 1928 a young female little piked whale was captured in a salmon trap operated by the Sebastian-Stuart Fish Company, probably on Whidby Island, and was brought to the foot of Spokane Street, Seattle. After being frozen, it was photographed (Figs. 49-50) and was returned to cold storage, where it now hangs from the ceiling. In 1945 we measured the length from tip of lower jaw to tail notch at 12 feet 9 inches, with an error of perhaps 3 inches either way due to the fact that we could not quite reach the specimen. Davis has given a brief popular account of the Frozen Fish Exhibit where the specimen is now held, including a front-view photograph of the whale (1941, pp. 13 and 34). Howard Langrud, in charge of the exhibit in 1945, told us that his recollection of the weight of the whale was 1,400 pounds.

At least on two occasions little piked whales have been killed in freshwater tributaries of Puget Sound. On April 1, 1929, W. H. Bennett and A. C. Woods found the carcass of a small whale stranded at the edge of McAllister Creek estuary in the Nisqually Valley, 2.5 miles from the southeast corner of Puget Sound. Their reports led many of the local people to visit the spot, one of whom, Mrs. John Anderson, placed a brief story accompanied by a photograph in the "Tacoma Daily Ledger" (April 3, 1929, p. 1; *cf.* also, "Tacoma News-Tribune" of same date). Two other photographs, taken by W. H. Bennett, have been examined by us. Finally, two plates of baleen (JWS 1113) were donated by Mrs. Fred A. Golson. From a study of these materials it is certain that the specimen was a small *Balaenoptera acutorostrata*.

The length of the animal, as recalled years later by eyewitnesses, has been given variously as from 7 to 14 feet. The only figure on record is that of Mrs. Anderson in her newspaper story, 11.5 feet. The color was apparently gray, or shades of gray, although traces of the characteristic white patterning of flippers and sides are apparent in photographs. The weight of the carcass

was estimated by news reporters as 500-800 pounds. No trace of the skeleton has been found. (Delbert J. McBride has kindly helped us in tracking down information on this specimen.)

Another specimen of the little piked whale is known to us only from two press clippings, dated March 8 and 9, 1938, perhaps from an Everett newspaper. The whale ascended the Snohomish River for a distance of over 10 miles before it was killed. The whale was seen and shot at 3 times on March 3 by Homer Stephens, living 3 miles upstream from the town of Snohomish. On March 6 Lena Stephens found the animal dead in shallow water a mile farther upstream. It was displayed on the following day in Everett and was slated to be sent to a reduction plant in Seattle. The length was recorded as 15.5 feet, and the mouth "was shaped like that of a humpback, sulphur-bottom or finback whale, and had baleen hanging from the upper jaw."

The skeleton of a small *Balaenoptera*, apparently *acutorostrata*, was photographed by Fred Irving on January 25, 1945, on the beach of Waadah Island, Neah Bay. He estimated that the whale had been dead for several months. "I picked up 3 small sections of the whale tooth [baleen] . . . about 11 inches long and about 3.5 inches wide at the base. One bunch has 24 pieces and the other bunch has 12 . . . the head [skull] is about 3.5 feet wide and . . . about 5 feet long. There are about 16 backbones held together, not much fat or meat on them" (*in litt.*). It is not unlikely that this whale was the victim of anti-submarine measures employed by the coastal patrol during the war.

Mr. Irving later supplied us with 2 bunches, totalling 52 blades, of baleen. The blades are mostly 18-18.5 cm long and 8-9 cm wide at the base; the fringe fibers long and fine (about 0.2 x 150 mm) on the inner edges of the blade

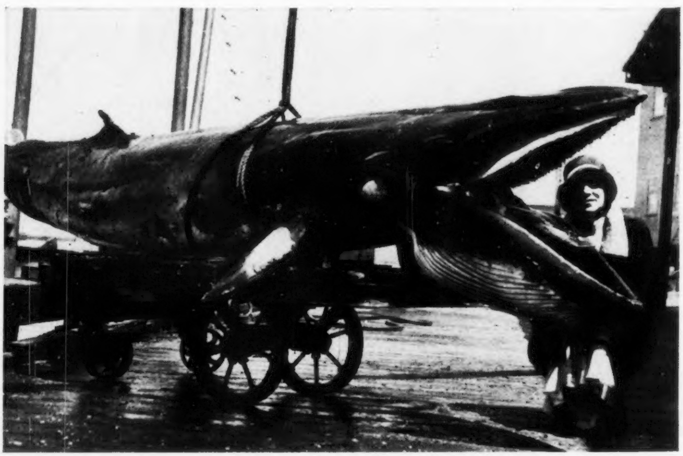


Fig. 50.—Same specimen as in figure 49; note white spot on flipper and short, light-colored whalebone. (Photo from Howard Langrud).

and shorter and coarser (0.7 x 60 mm) on the outer edges. The blades are the color of pale straw or horn, tinged with obscure gray and rosy streaks basally on their outer faces.

From the scarcity of specimens and observations it seems likely that little piked whales are only occasional visitors to Puget Sound waters south of the Strait. We have had reports from time to time of small whales, evidently not killers or humpbacks, that were probably of this species. Thus George Rodgers, a tugboat captain at Deception Pass, described a small whale "about the size of a blackfish" [killer whale] but with a rather low fin, about 1 foot high, which was seen regularly over a three-year period prior to the fall of 1941 in waters west of Deception Pass, that is, Smith Island, Thatcher Pass, and Smelt Bay. Mr. and Mrs. R. B. Shadduck, cruising in southern Henderson Bay in the spring of 1942 (April ?) saw a whale estimated to be 25 feet long, lacking the conspicuous high dorsal fin of the killer. Captain Draper, of the Edmonds-Port Ludlow ferry, who has travelled the Sound for many years, told us that he has not seen a large whale here for years but that he occasionally sees a small one, different from the "blackfish" [killer]. He is of the opinion that the small whales do not spout.

SIBBALDUS MUSCULUS (Linnaeus) 1758—Blue Whale, Sulfur-Bottom Whale

Prior to the advent of modern steam whaling the blue whale was little known on the Washington coast, mainly because of its great speed, size, and power and its habit of passing the Washington coast well out to sea. Quite certainly, too, it was never as abundant as the finback and humpback. According to Waterman (1920, p. 42) the blue whale was known to the Makah as *kwaqwawe axtLi,* or "noisy tail," perhaps because the whale, unlike the finback, lifts its tail flukes high as it dives. (A Makah native gave us the same name for the Stejneger beaked whale; see p. 267.) It is highly improbable that the Washington natives, with their simple equipment, attempted to capture the blue whale.

Only 13 blue whales were taken by the Bay City whalers over a 13-year period (Table 1). During the same period numbers of blue whales were being taken by shore stations north of Washington and, later, a great many were killed by the floating factories off the Lower California and California coasts (Radcliffe, 1933, Table 2). The California *shore* stations, like the Bay City station, had poor success in obtaining this valuable species of whale. We infer that the blue occurred only as a far-offshore migrant along the coast from southern California to British Columbia. The two taken in the 5 years considered in Table 2 were captured in September and October.

MEGAPTERA NOVAEANGLIAE (Borowski) 1781—Humpback Whale

The relative abundance of the humpback whale in Washington is reflected in the total catch at Bay City of 1,933 individuals, comprising 72 % of the total catch of all species (Table 1). On 7 occasions over the period 1913-

1919, a single killer ship took 4 humpbacks in one day's hunting. The humpback, although not as valuable individually as certain other species, was, in the aggregate, the most important of the Washington whales and the decline of the humpback population, even in the face of sustained kills of other species, brought the whaling to an end here.

The record catch of 252 humpbacks in 1915 marks the peak of production at Bay City and may be contrasted with the 100-per-year averages of 1923 and 1924. The decline in numbers of humpbacks was apparently due less to operations along the Washington coast than to increased intensity of whaling in California and Alaska, that is, the stock was most rapidly depleted at the extremities of the migratory range. Operations at Bay City, where the humpback was a main source of revenue, were finally suspended and the buildings were dismantled.

Certain information on the seasonal abundance of the humpback in Washington may be gleaned from Table 2. Over a 5-year period humpbacks were relatively scarce in late April and May. "Pacific Fisherman" notes, however, that a "California humpback" was taken as early as March 14 (v. 10, p. 24). The take of humpbacks increased sharply until August and then declined.

Whether the summer population of whales along the Washington coast is made up of residents or of migrants is not clear. In the case of active *migrants* we believe that the most effective method of hunting would be to intercept the run west of Bay City, but, on the other hand, if the whales are *residents,* the largest catch would be had by pursuing them over a wide field. In support of the idea that a summering population of humpbacks was responsible for the July-August peak at Bay City, whaling operations were extended farther and farther southward, to Cape Blanco, Oregon, in the later years of operation as the take of whales declined. Kellogg's description (1929) of the movements of humpbacks along the west coast of North America would seem to imply that the July and August records for our coast were stragglers from the main body migrating to Alaska.

A native of Lapush told us that whales in general are seen in greatest numbers off the village in April. The lightkeeper on Tatoosh Island said that whales are seen most often in March, playing in currents at the entrance to the Strait of Juan de Fuca.

The humpback is probably the commonest of the large whales visiting the inland waters of the state. As early as 1895 an old bull of this species was harpooned in Henderson Bay near the head of Puget Sound, and after towing the small boats of the whaling party for "five long days and nights" was finally dispatched, taken to Quartermaster Harbor, and then exhibited in Tacoma. The incident was described in the "Northwest Magazine" (Hill, 1897) and was mentioned later by True (1904, p. 275, pl. 41, figs. 1-4).

Large whales, usually single, are seen from time to time from the Seattle waterfront. One was described in the "Seattle Times" on November 14, 1926, and another on June 13, 1938. The latter item mentioned surface play characteristic of the humpback, although the whale was not positively identified.

In the editorial offices of the "Oregon Journal" (Portland) we saw a

photograph with the caption "Residents of Oyhut, Washington . . . inspect 'Moby Dick' 40-foot humpback whale a victim of poor navigation or illness, found on the beach Wednesday morning . . . March 5, 1938." The furrowed throat and long flippers of the humpback are clearly shown.

A humpback was seen by Verne Wright and Thor Jensen, crew members of a Foss tug, off Brown's Point on July 10, 1942. It was described as about 50 feet long, heavy set, slow of speed, with an odd fleshy bump on the end of its back, and an extremely wide tail which was lifted high and clear of the water in diving. Jensen had seen it lob-tailing on the surface at dawn on the previous day. The "Tacoma Times" for July 11 noted that "Submarine scare in Tacoma proves only 50-foot whale. . . . Local mariners . . . were unable to explain its presence in local waters inasmuch as all approaches from the sea are heavily guarded by Navy installations."

The only measurements of a humpback whale from Washington, so far as we know, are those given by True (1904, p. 276): "A skeleton from Pacific county, Washington, was exhibited in the World's Columbian Exposition in 1893. This specimen, according to a label attached to it, stranded at Long Beach, Pacific county, Washington, July 9, 1892. The length was 47½ feet and the girth 48 feet. The skeleton had the following vertebral formula: C.7, D.14, L.11, Ca.20 = 52."

Family BALAENIDAE, SMOOTH-THROATED WHALES

EUBALAENA SIEBOLDII (Gray) 1864—North Pacific Right Whale

No specimen records of the right whale in Washington are available, although Scammon stated that "in former years, the Right Whales were found on the coast of Oregon, and occasionally in large numbers; but their chief resort was upon what is termed the 'Kodiak Ground,' the limits of which extended from Vancouver's Island northwestward to the Aleutian Chain . . . the few frequenting the coast of California are supposed to have been merely stragglers from their northern haunts" (1874, p. 66).

The species is listed by Swan (1870) and Waterman (1920) as familiar to the Makah. It probably was successfully hunted by the natives in the years before its numbers were depleted by white men.

CETACEANS OF UNCERTAIN IDENTITY

Swan stated that "of the porpoise family there are three varieties in the waters of Fuca Strait. The large black kind called by the Makahs *a-ikh-petóhl;* white fin porpoise, called *kwak-watl,* and the 'puffing pig,' *tsailt'h-ko.* These are killed with harpoons of a smaller size than those used for whales, and are highly esteemed as food." (1870, p. 30.)

Information given us in 1942 by Fred Irving, a Makah living at Neah Bay, tallies fairly well with that obtained by Swan years before. Irving said that *a-akh-puch* or *a-akh-putl* means the sound of something striking the water. It is applied to a gray porpoise [*Delphinus* or *Lagenorhynchus?*], which travels

in schools of a hundred or more. It dives fast, is slender, and can be seen breaking water a mile away; "leaps out of the water like a greyhound." The skin is mostly gray all over, the meat is light, like pork chops, and is good to eat. The fur seals do not sleep but are alert when this porpoise is near. Swan's *kwak-watl* is certainly the same as Irving's *kw-kwacht-kle* and can definitely be ascribed to *Phocoenoides dalli* (*cf.* p. 303). Swan's *tsailt'h-ko* is Irving's *tseelkh-koo,* the harbor porpoise, *Phocoena vomerina* (p. 297).

A Quillayute native, Morton Penn, to whom we showed a picture of *Delphinus,* called the animal *cho-o-cho-bul* and said that the term is like the English "splash." We presume that the term is applied to any fast swimming dolphin, such as *Delphinus* and *Lagenorhynchus.*

The captain of an otter trawler working 5-30 miles off Cape Flattery says that he sees three kinds of porpoises: a savage, slim gray one that jumps clear of the water and does not play at the bow of the ship [*Delphinus?*] and two black-and-white ones that play at the bow and can be harpooned [*Lagenorhynchus* and *Phocoenoides?*].

In ancient middens at Lapush, Reagan found bones of "porpoise[?], sea lion, and bones of the following species of whale: sperm whale, black fish[?], fin-back, sulphur bottom, California gray, and killer whale" (1917, p. 15).

On March 5, 1939, the carcass of a small whale on the beach one-half mile north of the mouth of the Copalis River was visited by one of us after its presence had been mentioned in an Aberdeen newspaper. It proved to be 22 feet long and was badly decomposed; the teeth had been chopped out. In restrospect, we feel certain that it was a beaked whale. Unfortunately for the record, we were not particularly interested in cetaceans at the time of our visit.

In the Ferry Museum in Tacoma is a portion of a whale vertebra bearing the number 338(1?), found at Point Defiance, September 17, 1921, by "Raymond and Anderson" and donated by them. We have made no serious effort to identify it.

Mrs. Nina Eagan recalled seeing a large whale, 65 feet long, on the beach north of Steilacoom, about 30-35 years ago. T. D. Van Slyke, of Steilacoom, saw the same whale, said to be 90 feet long, in shallow water off Salter's Point in the summer of 1905(?). It died a week or so later and stranded head first in Chambers Creek. It was first displayed on Sunny Beach (Silvers Beach) and later at the Foss dock in downtown Tacoma. When the carcass became offensive it was towed out to sea.

On January 1, 1942, the man in charge at Sunnyside Beach north of Steilacoom told of a large whale he saw years ago while en route in a small boat from McNeil Island to the mouth of Chambers Creek. It was subsequently harpooned on the north side of the island and exhibited for a price on a barge at Tacoma. Its bones, including vertebrae about 2 feet in diameter, were stripped and piled along the railroad bed in downtown Tacoma. This whale and the finback at Shelton, were the only ones in Puget Sound recalled by our informant. The whale could have been, perhaps, the humpback of 1895 or the Steilacoom whale of about 1905.

SYNOPTIC KEY TO THE CETACEANS OF THE WEST COAST OF NORTH AMERICA*

1. *Whalebone* (i.e., flexible, horny, fringed plates hanging in rows from the roof of the mouth on each side of the upper jaw) *present; teeth absent; blowhole double* (Mysticeti) 2

1. *Whalebone absent; teeth present* though sometimes concealed beneath the gums; *blowhole single* (Odontoceti) 9

2. *Back fin present* (Balaenopteridae) 3

2. *Back fin absent* 7

3. *Flippers extremely long, nearly one-third length of body, each with scalloped lower margin;* average length of body 45 feet; furrows on outer skin of throat 14-30, extending well down to stomach; back black; stomach mottled with gray and white; flippers sometimes white on outer sides. Whalebone 22-24 inches in length, grayish black; bristles 4-6 inches in length, forming matted mass; average number of plates 400 per side ....HUMPBACK WHALE, p. 321

3. *Flippers much less than one-third length of body, not scalloped below* (Rorquals or Fin-Whales) 4

4. *Whalebone yellowish white or slate-colored, or both* 5

4. *Whalebone black or nearly black* 6

5. *Right front series of whalebone plates* (comprising 130-175) *white, remainder yellow or slaty; average length of body 60 feet;* numerous throat furrows extending well back on stomach; color dull grayish brown on back (rapidly darkening to black on death) to white on belly; under side (inner side) of flippers white; under side of tail flukes white; length of flipper about one-ninth that of body. Whalebone 20-36 inches in length, hairy fringes white or yellowish with bristles 2-10 inches in length; average number of plates 430 per side ....FINBACK WHALE, p. 311

5. *Distinct white mark on middle of flipper; average length of body 25 feet;* numerous throat furrows extending well back on stomach; color blue-gray on back to ivory white on stomach; under side of tail flukes white. Whalebone to 8 inches in length; color white or yellowish; average number of plates 260 per side ....LITTLE PIKED WHALE, SHARP-HEADED FINNER WHALE, p. 317

6. *Whalebone black, with coarse black hairs; snout* (from above) *broadly U-shaped;* average length of body 75 feet; *numerous throat furrows extending at least to navel;* length of flipper never more than one-tenth that of body; *dorsal fin nearer tail than flipper;* color bluish gray, darker on head, lips, and throat and paler along sides; stomach often with yellowish cast and occasional small scattered white marks; lower side of tail flukes colored like body. Whalebone 23-32 inches in length; average number of plates 370 per side ....BLUE WHALE, SULFUR-BOTTOM WHALE, p. 321

6. *Whalebone mostly black with fine, white curling hairs; snout* (from above) *pointed;* average length of body 45 feet; *numerous throat furrows ending some distance ahead of navel; dorsal fin about midway between flipper and tail;* color dark blue or brownish above, usually spotted, with little white below; under surface of tail flukes bluish gray. Whalebone 10-25 inches in length; average number of plates 325 per side ....SEI WHALE, p. 317

* Only the more important characters are given. For fuller descriptions and, in many cases, illustrations the reader is referred to: British Museum (1922, 1923), Fraser (1946), Kellogg (1940), Norman and Fraser (1938), Scammon (1874), True (1889 and 1910), United States Coast Guard (1937).

7. *Skin of throat furrowed or grooved; cervical vertebrae distinct; right and left sides of lower lips not arched;* average length of body 42 feet; furrows on either side of throat 2-3; color mottled gray overall, varying in individuals from light gray to almost black. Whalebone about 18 inches in length, yellowish toward front of mouth and often gray toward back; average number of plates 182 per side ....GRAY WHALE, p. 310

7. *Skin of throat smooth; cervical vertebrae fused; right and left sides of lower lips strongly arched* (Balaenidae) 8

8. *Head enormous, one-third length of body; whalebone very long, 10-14 feet;* average length of body 50 feet; flippers short and heavy; body black except for white throat and occasional white spots on stomach. Whalebone black; average number of plates 330 per side ....BOWHEAD WHALE, GREENLAND WHALE, *Balaena mysticetus.* (A resident of arctic and subarctic seas; not reported from Washington).

8. *Head one-fourth to one-fifth length of body;* average length of body 50 feet; body black, more or less whitish on throat; bonnet (i.e., fleshy top of head near snout) often infested with crustaceans. *Whalebone long,* 6-9 feet, black; average number of plates 250 per side ....NORTH PACIFIC RIGHT WHALE, p. 323

9. *Head extending well beyond tip of lower jaw; concavity of blowhole facing to side or slightly backward, teeth normally present in lower jaw only* (Physeteridae, Sperm Whales) 10

9. *Lower jaw extending at least as far as tip of snout; concavity of blowhole facing forward; teeth usually present in both upper and lower jaws* 11

10. *Length of males to 60 feet, of females to 30 feet;* snout bluntest of any cetacean, almost rectangular in side view; *dorsal fin replaced by several irregular bumps;* back blackish brown, sides and underparts lighter and grayer; *18-28 teeth on each side of lower jaw, strong and heavy;* rarely several small teeth in upper jaw ....SPERM WHALE, p. 304

10. *Length to 13 feet, females probably shorter; dorsal fin well defined;* body black above and grayish white beneath; *up to 15 pairs of teeth in jaw, small and weak;* rarely several teeth in upper jaw ....PYGMY SPERM WHALE, p. 307

11. *Dorsal fin absent* 12

11. *Dorsal fin present* 14

12. Length to 8 feet; *head elongated, with a distinct beak; several cervical vertebrae fused; body black with sharply contrasting white chin, breast, and line along belly* ....RIGHT WHALE DOLPHIN, p. 269

12. Length to 17 feet; *head blunt, without a beak; cervical vertebrae distinct; color white to dull mottled gray or grayish brown* (Delphinapteridae) 13

13. *With teeth in both jaws; usually 10 pairs in upper and 8 pairs in lower;* length of body to 17 feet; *adults white overall;* young dark brown, bluish, or grayish white ....WHITE WHALE, BELUGA, p. 303

13. *Without visible teeth* (female) *or with distinctive spiral tusk several feet in length* (male); length of body to 16 feet; *adults gray,* mottled with black, darker above ....NARWHAL, *Monodon monoceros.* (A resident of arctic seas; not reported from Washington).

14. *Skin of throat with 2 conspicuous grooves; hind margin of tail flukes smooth;*

dorsal fin well behind middle of body (Ziphiidae, Beaked Whales) 15*

14. *Skin of throat smooth; tail flukes with median notch; dorsal fin at, or near, middle of body* 18

15. *Forehead prominent, rising abruptly from, and almost at right angles to, axis of beak* 16

15. *Forehead not prominent, merging gradually into beak* 17

16. Length of male to about 30 feet, female to about 24 feet; *one pair of teeth at tip of lower jaw, usually concealed in the gum,* rarely a second pair of smaller teeth behind these; *teeth oval in cross-section;* small vestigial teeth often buried in gums of upper and lower jaws; distance from tip of snout to blowhole 14-22% of body length; color variable, from dark above and light below to mottled, or almost pure creamy white ....
BOTTLENOSE WHALE, *Hyperoodon rostratus.* (Not reported from the eastern Pacific but said to occur in the western Pacific and Bering Sea; see p. 266.)

16. Length of male to about 42 feet, female smaller; *two pairs of teeth at tip of lower jaw,* forward pair about 3 inches long, hinder pair about 2 inches long, *teeth elliptical in cross-section;* color blackish above and whitish below ....
....BAIRD BEAKED WHALE, p. 266

17. *Length to 28 feet;* distance from tip of snout to blowhole 10.4-12.6% of body length; single pair of teeth at end of lower jaw protruding an inch or more beyond the gum, concealed in females; *diameter of teeth in males, to 1½ inches; strongly marked medial keel dorsal fin to tail;* color of little diagnostic value, varying from brown to purplish black with creamy white areas; skin often scarred by teeth of fellow whales ....
......CUVIER BEAKED WHALE, *Ziphius cavirostris.* (Not reported from Washington).

17. *Length to 17 feet; single pair of massive, roughly triangular teeth near middle of each lower jaw, concealed in females; male tooth about 5¾ inches along anterior border, 8¼ inches along posterior border, 3¼ inches from anterior to posterior border, and ½ inch thick;* male tooth often projecting above top of snout ....STEJNEGER BEAKED WHALE, p. 267**

18. *Teeth at front end of lower jaw only, 2-7 pairs;* length of body to 13 feet; back fin high and recurved; color: males bluish white with dark brown patches, females uniform brown; forehead rising almost perpendicularly from upper lip
..............RISSO DOLPHIN, *Gramphidelphis griseus.* (Not reported from Washington).

18. *Teeth in both upper and lower jaws, 8 or more pairs* 19

19. *Length 20-30 feet; teeth 8-13 on each side in each jaw* 20

19. *Length less than 12 feet, usually less than 9; teeth more than 15 on each side in each jaw* 22

20. *Forehead greatly swollen, almost globular, overhanging the tip of the very short beak; teeth 8-12 pairs in forward end of each jaw;* length of body to 28 feet; flippers narrow, about one-fifth of body length; color black, frequently with a

---

* Beaked whales in the flesh are difficult to identify. Members of a decadent group, they vary greatly in color, dentition, and skeletal characters. For this reason, as well as for the reason that few specimens have been studied by naturalists, descriptions of the various beaked whales are not very satisfactory. Perhaps the best way to identify a beaked whale is to send its skull, or one side of the lower jaw, to the National Museum for comparison with named specimens. Our synopses of the four North Pacific genera of beaked whales—*Hyperoodon* (?), *Berardius, Mesoplodon,* and *Ziphius*—are based on the meager information at hand.

** The finding of a similar species, *M. bowdoini,* in California has recently been reported by Hubbs (1946).

longitudinal white stripe on under surface expanding into a heart-shaped figure on throat .... BLACKFISH, PILOT WHALE, p. 289

20. *Forehead not prominent; teeth 10-13 pairs in each jaw, not restricted to forward* end of jaw 21

21. *Color black and white; flippers rounded;* teeth 10-14 on each side in each jaw, *elliptical in cross-section, about 1 inch in diameter,* powerful; *back fin, at least in males, 5-6 feet high;* body length: males to 28 feet, females to 15 feet .... KILLER WHALE, p. 274

21. *Color black overall; flippers pointed;* teeth 8-12 on each side in each jaw, *circular in cross-section, ½ to ¾ inch in diameter; back fin low and recurved;* body length to 18 feet .... FALSE KILLER WHALE, p. 287

22. *Head without distinct beak* 23

22. *Head with beak marked off from forehead* 24

23. *Teeth spade-shaped; body grayish or grayish-black above, color extending gradually through mottled zone to white or gray beneath;* length to 6 feet .... HARBOR PORPOISE, p. 289

23. *Teeth conical, nearly buried in rough, hard pits in gums; body jet black above* (washed with gray on tips of back fin and tail flukes), *contrasting sharply with white patch on belly and flanks,* patch extending forward at least to back fin; fin-like ridge, low but distinct, shortly ahead of tail flukes; length of body to 6 feet .... DALL PORPOISE, p. 301

24. *Beak short and rim-like, 2-3 inches in length* 25

24. *Beak elongated, up to 6 inches* 26

25. Length of body to 12 feet; *teeth ⅜ inch in diameter, 20-26 visible on each side in each jaw;* color, purplish lead-gray to black or gray-brown above, white beneath, dark from vent to tail flukes, white on upper lip, *sides without longitudinal bands of color* .... BOTTLENOSE DOLPHIN, *Tursiops gillii.* (Not reported from Washington. Another species, *T. nuuanu,* may occur in warm waters of the Pacific, according to Andrews, 1911).

25. Length of body to 9 feet, females slightly smaller than males; *teeth less than ¼ inch in diameter, about 34 pairs in upper jaw and 30 pairs in lower; longitudinal bands, in shades of black and white, along sides of body* .... STRIPED DOLPHIN, p. 270

26. *Sides with undulating, horizontal bands of white or creamy; spectacle-like, dark streak around eyes and across beak;* length of body to 8½ feet; teeth 40-50 on each side in each jaw, slender .... BAIRD DOLPHIN, COMMON DOLPHIN, p. 269

26. *Sides of body without bands;* length of body to 7 feet; color dark purplish gray above, grayish white beneath; many white or gray spots on back and sides; teeth to 47 on each side in each jaw .... LONG-SNOUTED DOLPHINS, *Stenella longirostris, S. graffmani,* and *S. euphrosyne.* (Not reported from Washington. See Lönnberg, 1934, and Kellogg and Scheffer, 1947).

TABLE 1.—Whales received annually at Bay City, Washington, and number of killer ships operating, 1911 to 1925[1]

Year	Blue	Finback	Humpback	Sei	Sperm	Bottlenose	All Species	Killer Ships Number	Killer Ships Season
1911	2	5	173		2		182	2	?
1912	4	57	198			2	261	4	Started March 14 or earlier
1913		43	161		6		210	2	April 14 - July 31
								3	August 1 - October 2
1914		62	127		3		192	2	April 17 - June 30
								3	July 1 - October 1
1915	1	66	252		15		334	3	April 27 - July 13
								4	July 14 - September 13
1916		122	137		9		268	4	?
1917	3	40	157		9		209	4	?
1918		41	126	2	15	3	187	4	April 20 - June 20
								3	June 21 - October 19
1919	1	26	122	5	19	1	174	3	April 24 - October 14
1920	1	22	138	12	14		187	3	?
1922	1	27	124		9	2	163	?	?
1923		23	99		14		136	4	?
1924		68	98	2	5		174[2]	?	?
1925			21				21	?	Ended June 10
Totals	13	602	1933	21	120	8	2698[2]		

1 No whaling in 1921 because of poor market.
2 Includes one gray whale reported taken in 1924 (Kellogg, 1931, p. 74).

Table 2.—Whales received at Bay City, Washington, over a selected five-year period (1913-1915, 1918-1919), as related to catch effort.

Month	Blue	Finback	Humpback	Sei	Sperm	Bottlenose	All Species	Ship Days	Whales per Ship Day
April (part)		17	7	2		1	27	139	0.194
May		54	51	3	9	1	118	434	0.272
June		65	151		18		234	410	0.571
July		21	215		9	1	246	452	0.544
August		34	262		9		305	496	0.615
Sept. (part)	1	47	88			1	137	412	0.333
Oct. (part)	1	3	14		13		31	108	0.287
Totals	2	241	788	5	58	4	1098	2451	0.448

TABLE 3.—Output of whale products at Bay City, Washington, in selected years from 1913 to 1925[1]

	Oil, barrels (50 gallons each)			Fertilizer, tons			
Year	Body	Sperm	Total	Bone	Meat	Total	Other products[2]
1913	5362	318	5680	?	?	376	Spermaceti, 25 bbls.[3]
1914	5205	149	5354	231	250	481	Spermaceti, 22 bbls., Baleen, 3000 lbs.
1915	6300	632	6932	100	380	480	Spermaceti, 101 bbls., Baleen, 15,000 lbs.
1916	14000	160	14160	90	300	390	Baleen, 10,000 lbs.
1918	4590	860	5450	176	373	549	Spermaceti, 195 bbls. Bottlenose oil, 39 bbls.
1919	4160	1040	5200	168	331	499	Spermaceti, 326 bbls., Bottlenose oil, 13 bbls.
1920	5035	990	6025	221	330	551	?
1922	4670	660	5330	150	274	424	?
1923	?	?	?	142	220	362	?
1924	?	?	?	107	197	304	?
1925	?	?	?	68	37	105	?

1 From Radcliffe (1933, Table 2) and records of the American Pacific Whaling Company for 1913-1915 and 1918-1919. In cases where our source materials are not in agreement, we have favored the data of Radcliffe.

2 In addition to the products listed below, the following were prepared at all Pacific Coast whaling stations from California to Alaska: in 1918 ivory, frozen and canned meat; in 1919 ivory and frozen meat; in 1920 and 1922 ivory; in 1923 canned meat; in 1925 carcasses for fox feeding (Radcliffe, 1933, footnote p. 33). "Pacific Fisherman Year Book" (1918, p. 103) reported that the Guilford Packing Company, of Westport, Washington, put up 250 cases of "tenderloin" of whale in 1917.

3 Values for spermaceti and bottlenose oil in this column are included under sperm oil at the left of the table.

TABLE 4.—Catalog of specimens of harbor porpoises from Washington

(In chronological order; data abbreviated. Important measurements are given when the specimen is not described elsewhere in this paper. Fetal specimens are listed with the mother. Letters *j* and *p* refer to juvenile and pregnant. See also Tables 5 and 6.)

USNM 4149 — 1860 (catalogued); Puget Sound; C. B. R. Kennerly; rostrum and part of brain case; *cotype*.

USNM 9077 — 1869; Puget Sound, C. M. Scammon; skull and mandibles with teeth, nearly intact. This or the next-listed is probably the male (length 4 feet 8 inches) obtained by Scammon at Port Townsend on April 28, 1869, of which 19 measurements are given (1874, pp. 95-96).

USNM 9078 — 1869; Puget Sound; C. M. Scammon; skull and mandibles with teeth, nearly intact.

USNM 36591 — 1893 (catalogued); Jefferson Co., Port Townsend; James G. Swan; juvenile skull and mandibles with teeth; fair shape.

TABLE 4.—(Continued).

USNM	83990	—	1895; King Co., Seattle; C. H. Townsend; broken mandible, no teeth.
JWS	1127	—	1915 (about); Pierce Co., Steilacoom, beach at mouth of Chambers Creek; eroded cranium and broken mandible saved by Deep Sea Aquarium, Steilacoom; total length 266.
JWS	1126	—	Date? Puget Sound near Steilacoom; eroded cranium of subadult; saved by Deep Sea Aquarium; total length ca. 272.
JWS	1208	j ♀	1932 (about); Grays Harbor Co., Pacific Beach; dead on beach; saved in formalin by Deep Sea Aquarium (see Table 6).
WSM	12007	—	1934, November 10; Strait of Juan de Fuca, Sooke Inlet; harpooned from the M. S. CATALYST; skull and partial skeleton; total length 257, basilar length 253, zygomatic breadth 144.
USNM	249455	—	1934, November?; at sea 20 mi. SW Tatoosh Island; dredged by trawler MADELINE J; adult cranium, broken, no teeth; saved by International Fish. Commission, Seattle.
USNM	249456	—	1934 (about); probably Washington coast; dredged by trawlers?; subadult cranium, no teeth; saved by International Fish. Commission, Seattle.
JWS	———	—	1935, August; one of two taken in purse seine on Swiftsure Banks by seiner EMBLEM; photographs only, taken by Frank Puz, saved by JWS as lot no. 45302a1; standard length about 4.5-5 feet.
MVZ	86878	♂	1938, September 28; Pacific Co., mouth of Naselle R.; found dead on beach; skull; total length 264, basilar length 259, zygomatic breadth 147.
WWD	1568	—	1939, August; Whatcom Co., Point Roberts; in fishing gear; fragments of mandibles.
VBS	——	♂	1941; Puget Sound or Washington coast; in otter trawl; photographs only, taken by H. E. Lokken, saved by VBS as lot no. 1470.
VBS	1254	j ♂	1941; Puget Sound; in fishing gear; entire frozen specimen; skull and photos saved (see Table 6 and Figs. 25-26).
VBS	1266	p ♀	1942, April; Pacific Co., Ocean Park; dead on beach; broken skull; ♂ fetus lost.
JWS	1206	p ♀	1942, April 22; Pierce Co., mouth of Henderson Bay, in net at 32-44 fathoms; weight 175 lbs.; mutilated skull and ♂ fetus in formalin (see Table 6; Figs. 29-30).
JWS	1207	p ♀	1942, April 22; Pierce Co., mouth of Henderson Bay, in net at 32-44 fathoms; weight 175 lbs.; adult lost, ♂ fetus saved in formalin (see Table 6).
VBS	1270	p ♀	1942, May 19, Grays Harbor Co., ¾ mi. N Grayland; dead on beach; skull and ♀ fetus (see Tables 5 and 6; Fig. 27).
VBS	1273	—	1942, May?; Clallam Co., 2 mi. S Lapush; dead on beach; skull.
——	——	♀	1942, July; Grays Harbor Co., Grayland; dead on beach (see Table 6).

TABLE 4.—(Continued).

——	——	♂	1942, August; Grays Harbor Co., Ocean City; dead on beach; nothing saved; standard length 50 inches (127 cm) according to Kelshaw Bonham and Don McKernan.
VBS	1293	p♀	1943, January; Clallam Co., Neah Bay; dead on beach; skull and ♂ fetus (see Tables 5 and 6).
VBS	1294	p♀	1943, February 24; Clallam Co., 16 mi. SW Lapush; in net at 40 fathoms; skull and ♀ fetus (see Tables 5 and 6).
VBS	1295	p♀	1943, February 28; Washington seacoast; in gill net; skull and ♀ fetus (see Tables 5 and 6; Figs. 31-34).
VBS	1303	——	1944, March 30; Jefferson Co., 14 mi. W Destruction Island; dredged; eroded cranium, broken and without teeth; original basilar length ca. 295.
VBS	1307	p♀	1945, January 20; Skagit Co., Samish Flats; in net at 4.5 fathoms; skull, pelvic rudiments, and ♀ fetus (see Tables 5 and 6).
VBS	1308	p♀	1945, March 13; Clallam Co., 40 mi. W by S Tatoosh Island, in net at 40 fathoms; skull, pelvic rudiments, and ♂ fetus (see Tables 5 and 6; Fig. 28).

TABLE 5.—Measurements of 6 adult female harbor porpoises from Washington

(Arranged in order of body length. For dates and localities, see Table 4. All were pregnant; for measurements of fetuses see Table 6.)

Collector	VBS	VBS	VBS	VBS	VBS	VBS
Catalog number	1307	1295	1294	1293	1270	1308
Weight in pounds (actual)	119	122	162	155	130	166
Weight in kilograms (computed)	53.9	55.3	73.4	70.3	58.9	75.2
Snout to base of tail notch	1562	1664	1680	1734	1740	1785
Girth behind flippers	884		900	870	840	940
Maximum width across tail flukes	379	380	414	420	404	470
Snout to tip of dorsal fin	915		1025	965		1020
Snout to insertion of flipper	341	343	342	345		344
Axillary length of flipper[1]	177	215	225	220	211	208
Maximum width of flipper	82	84	86	86	84	84
Height of dorsal fin	106		110	96	102	103
Tail notch to center of anus	479	506	544	517	541	560
Tail notch to center of umbilicus	951				1095	1120
Length of anal-genital slit	148				241	
Distance between mammary slits	56		43		56	64
Snout to corner of mouth	137	138	138	131	144	137
Middle lower lip to corner of mouth		141	140	133	146	143
Snout to center of eye	190	188		92		
Dimensions eye opening				9x18	9x16	
Snout to transverse slit blowhole		197	207	194	205	
Max. transverse width blowhole		30	31	31	33	

[1] Applies only to Nos. 1307 and 1308; all other lengths are *axial*.

TABLE 6.—Lengths and weights of 11 young harbor porpoises from Washington

Specimen Number	Sex	Date	Locality	Length, mm	Weight kilo-grams	Weight pounds
			Fetal			
VBS 1307	F	January 20	Samish Flats	239	0.254	0.559
VBS 1293	M	January 1?	Neah Bay	258	0.325	0.716
VBS 1294	F	February 24	At sea	384	1.076	2.37
VBS 1295	M	February 28	At sea	411	1.098	2.42
JWS 1206	M	April 22	Henderson Bay	480	1.650	3.63
VBS 1308	M	March 13	At sea	486	1.701	3.75
JWS 1207	M	April 22	Henderson Bay	510	1.952	4.30
VBS 1270	F	May 19	Grayland	660	3.523	7.76
			Juvenal			
JWS 1208	F	1932 (?)	Pacific Beach	765	7.991[1]	17.6
Not saved	F	July 15 (?)	Grayland	780[2]	——	——
VBS 1254	M	Fall[3]	Puget Sound	1057	15.76	34.7

[1] Eviscerated specimen in formalin; weighed after replacing viscera with water.

[2] Measured on beach by Kelshaw Bonham and Don McKernan.

[3] Recovered in frozen condition from a Seattle fish market on October 15, 1941.

REFERENCES

ANDREWS, ROY CHAPMAN 1909—Observations on the habits of the finback and humpback whales of the eastern North Pacific. Bull. Amer. Mus. Nat. Hist., v. 26, pp. 213-226, pls. 30-40.

———1911—Description of an apparently new porpoise of the genus *Tursiops*, with remarks upon a skull of *Tursiops gillii* Dall. Bull. Amer. Mus. Nat. Hist., v. 30, pp. 233-237, pl. 10.

ARSENYEV, V. A., B. A. ZENKOVICH, S. M. KAGANOVSKAYA, P. G. NIKULIN, AND I. I. KHARKOV 1937—On the hunting and utilization of sea animals and sharks in the Far East. Bull. Pac. Sci. Inst. Fisheries and Oceanography, Vladivostok, v. 10, pp. 1-115, illus. [In Russian].

BAILEY, VERNON 1936—The mammals and life zones of Oregon. N. Amer. Fauna, v. 55, pp. 1-416, illus.

BOAS, FRANZ 1909—The Kwakiutl of Vancouver Island. Memoirs Amer. Mus. Nat. Hist., v. 8, pt. 2, pp. [305]-522, pls. 27- 52, text figs. 32-173. (Reprint from v. 5, pt. 2, of the Jesup North Pacific Expedition).

BRADNER, ENOS 1944—Blackfish still a mystery: charge that it eats salmon not yet proven. Seattle Times, March 19, p. 19, 2 photos.

BRITISH MUSEUM 1922—Guide to the whales, porpoises, and dolphins (Order Cetacea), exhibited in the department of zoology. London, 2nd ed., 48 pp., 32 figs.

———1923—British whales, dolphins, and porpoises. Nat. Hist. Mus. Form 123, ed. 3, pp. 1-6.

BROCKLESBY, H. N. 1941—The chemistry and technology of marine animal oils with

particular reference to those of Canada. Fish. Research Board of Canada, Bull. 59, pp. 1-442.

CASSIN, JOHN 1858—Mammalogy and ornithology. *In* United States Exploring Expedition . . . under the command of Charles Wilkes, v. 8, 466 pp., illus.

CHAPMAN, WILBERT M. 1940—A right whale dolphin collected in Washington. Murrelet, v. 21, no. 1, p. 10.

COLLINS, J. W. 1892—Report on the fisheries of the Pacific coast of the United States. *In* Report of the U. S. Commissioner of Fisheries for 1888. (Washington, Govt. Printing Off.), pp. 3-269, illus.

COUCH, LEO K. 1930—Humpback whale killed in Puget Sound, Washington. Murrelet, v. 11, no. 3, p. 75.

COWAN, IAN MCTAGGART 1939—The sharp-headed finner whale of the eastern Pacific. Jour. Mamm., v. 20, no. 2, pp. 215-225. 3 pls., 3 tbls., 3 figs.

CURTIS, EDWARD S. 1913—Salishan tribes of the coast; Chimakum, Quilliute, Willapa. *In* The North American Indian. . . . (Plimpton Press, Norwood, Mass.), v. 9, pp. 1-153, illus.

DALL, W. H. 1869—Note on the "blowing" of whales. Amer. Nat., v. 3, pp. 333-334.

DAVIS, CAMPBELL 1941—Ichthyology at 40° below. Western Sportsman, v. 7, no. 3, pp. 11-13, 34; 12 photos.

DOUGHERTY, ELLSWORTH C. 1943—Notes on the lungworms of porpoises and their occurrence on the California coast. Proc. Helminth. Soc. Wash., v. 10, no. 1, pp. 16-22.

FRASER, F. C. 1946—Twelfth report on Cetacea stranded on the British coasts from 1933 to 1937. British Museum (Nat. Hist.), 56 pp., 11 figs., 7 maps.

GEITHMANN, HARRIET 1935—Friday Harbor's nets and dredges. Nat. Hist., v. 36, no. 1, pp. 73-80, 13 photos.

GUBERLET, JOHN E. 1936—Note on embryo porpoise. Murrelet, v. 17, nos. 2-3, p. 57.

HARMER, S. F. 1927—Report on cetacea stranded on the British coasts from 1913 to 1926, no. 10. Brit. Mus. (Nat. Hist.), 91 pp., 42 text figs., 7 maps.

HEIZER, ROBERT F. 1943—Aconite poison whaling in Asia and America: An Aleutian transfer to the New World. Bull. Bur. Amer. Ethnol. 153, Anthrop. Pap. 24, pp. 415-468, pls. 18-23A.

HILL, MERIDEN S. 1897—Vanquishing a whale. Northwest Mag., May, p. 6, 1 photo.

HUBBS, CARL L. 1946—First records of two beaked whales, *Mesoplodon bowdoini* and *Ziphius cavirostris*, from the Pacific coast of the United States. Jour. Mamm., v. 27, no. 3, pp. 242-255, pls. 1-4.

KELLOGG, REMINGTON 1929—What is known of the migrations of some of the whalebone whales. Ann. Rept. Smithsonian Inst., 1928, pp. 467-494, illus.

———1931—Whaling statistics for the Pacific coast of North America. Jour. Mamm., v. 12, no. 1, pp. 73-77.

———1940—Whales, giants of the sea. Nat. Geogr. Mag., v. 77, no. 1, pp. 35-90, illus., incl. 24 col. pls. by Else Bostelmann.

——— AND VICTOR B. SCHEFFER 1947—Occurrence of *Stenella euphrosyne* off the Oregon coast. Murrelet, v. 28, no. 1, pp. 9-10, figs. 1-2.

LÖNNBERG, EINAR 1934—*Prodelphinus graffmani* n. sp. a new dolphin, from the Pacific coast of Mexico. Arkiv för Zoologi [Stockholm], band 26A, häfte 4, no. 19, pp. 1-11, pl. 1.

MILLER, G. S., JR. 1920—American records of whales of the genus *Pseudorca*. Proc. U. S. Nat. Mus., 57, pp. 205-207, pls. 27-31.

NIDEVER, H. B. 1921—Black fish near Santa Catalina Island. Calif. Fish and Game, v. 7, no. 1, p. 64.

NORMAN, J. R., AND F. C. FRASER 1938—Giant fishes, whales, and dolphins. (New York, W. W. Norton and Co.), 361 pp., illus.

ORR, ROBERT T. 1937—A porpoise chokes on a shark. Jour. Mamm., v. 18, no. 3, p. 370.

OSGOOD, W. H. 1901—Natural history of the Queen Charlotte Islands, British Columbia. Natural history of the Cook Inlet region, Alaska. N. Amer. Fauna 21, 87 pp., illus.

———1904—A biological reconnaissance of the base of the Alaska Peninsula. N. Amer. Fauna 24, 86 pp., 7 pls. incl. 2 maps.

PACIFIC FISHERMAN 1903—(Miller Freeman Publications, Seattle, Washington). Published monthly, with an additional Year Book or Annual Statistical Number in January.

RADCLIFFE, LEWIS [1933]—Economics of the whaling industry and conservation measures, with appendices. *In* Report pursuant to S. Res. 246, . . . [Washington, U. S. Govt. Print. Off.], 79 pp. incl. tables. (73rd Cong., 2d Sess., Senate committee print.)

REAGAN, ALBERT B. 1909—Animals of the Olympic Peninsula, Washington. Proc. Indiana Acad. Sci., 1908, pp. 193-199.

———1917—Archaeological notes on western Washington and adjacent British Columbia. Proc. Calif. Acad. Sci., 4 ser., v. 7, pp. 1-31, pls. 1-6.

———1925—Whaling of the Olympic Peninsula Indians of Washington. Nat. Hist., v. 25, pp. 24-32.

ROBBINS, LEWIS L., FRANCES K. OLDHAM, AND E. M. K. GEILING 1937—The stomach contents of sperm whales caught off the west coast of British Columbia. Rept. Brit. Col. Mus., 1937, pp. L19-L20, 1 pl. with 3 figs.

SCAMMON, C. M. 1872—On a new species of Balaenoptera. Proc. Calif. Acad. Sci., v. 4, pp. 269-270.

———1874—The marine mammals of the north-western coast of North America, described and illustrated: together with an account of the American whale-fishery. (San Francisco, J. H. Carmany and Co.), 319 pp., illus.

SCHEFFER, VICTOR B. 1940—The sea otter on the Washington coast. Pacific Northwest Quarterly, v. 3, no. 3, pp. 370-388, figs. 1-5.

———1942—Further records of the Dall porpoise in California. Jour. Mamm., v. 23, no. 2, p. 221.

——— AND JOHN W. SLIPP 1944—The harbor seal in Washington state. Amer. Midl. Nat., v. 32, no. 2, pp. 373-416, figs. 1-17, tables 1-5.

SHEPHERD, GEORGE S. 1932—Killer whale in slough at Portland, Oregon. Jour. Mamm. v. 13, no. 2, pp. 171-172.

STARKS, EDWIN C. 1922—A history of California shore whaling. Calif. State Fish and Game Comm., Fish. Bull. 6, 38 pp., illus.

SWAN, JAMES G. 1857—The northwest coast; or, three years' residence in Washington Territory. (New York, Harper & Brothers), 435 pp., illus.

———1870—The Indians of Cape Flattery, at the entrance to the Strait of Juan de Fuca, Washington Territory. Smithsonian Contrib. Knowl., v. 16, art. 8, contrib. 220, pp. x, 108, illus.

TANAKA, SHIGEHO 1934—Suisan-doshoku butsu zusetsu [aquatic products of commerce]. (Tokyo, Daichishoin) 607 pp., illus., col. pls. [In Japanese, with index to Latin names.]

TAVERNER, P. A. 1943—Do fishes prey upon sea-birds? Ibis, v. 85, p. 347.

THWAITES, R. G. (ed.) 1904-05—Original journals of the Lewis and Clark Expedition, 1804-1806. (New York, Dodd, Mead & Co.), 7 vols. and atlas, illus.

TOMILIN, A. G. 1938—Le hypéroodon (*Hyperoodon rostratus* Pontop.) et les petits baleinoptères (Balaenopteridae) de l'Extrême-Orient. Bull. Soc. Nat. Moscou, sect. biol., n. s., v. 47, no. 3, pp. 210-217, 1 table. [In Russian, with French résumé.]

TOWNSEND, CHARLES W. 1929—The white whale at Ipswitch, Massachusetts. Jour. Mamm., v. 10, no. 2, p. 171.

TRUE, FREDERICK W. 1889—Contributions to the natural history of the cetaceans, a review of the family Delphinidae. Bull. U. S. Nat. Mus. 36, 191 pp., 47 pls.

———1904—The whalebone whales of the western North Atlantic compared with those occurring in European waters, with some observations on the species of the North Pacific. Smithsonian Contrib. Knowl., v. 33, pp. vii+332, illus.

———1910—An account of the beaked whales of the family Ziphiidae. . . . Bull. U. S. Nat. Mus. 73, pp. 89, pls. 42.

U. S. COAST GUARD—1937—General information for the ready identification of the principal types of whales. [Washington, D. C., for departmental use], 17 pp., illus.

U. S. WEATHER BUREAU 1938—Atlas of climatic charts of the oceans. Weather Bureau no. 1247, pp. vi, 65; 130 charts.

WAILES, G. H., AND W. A. NEWCOMBE 1929—Sea lions. Museum and Art Notes (Art, Historical, and Scientific Assn., Vancouver, B. C.), v. 4 no. 2, pp. [3]-10, 3 figs., cover pl.

WATERMAN, T. T. 1920—The whaling equipment of the Makah Indians. Univ. Wash. Pub. Political and Social Sci., v. 1, no. 1, pp. 1-67, pls. 1-8, 15 text figs.

WHALE PRODUCTS COMPANY, 1907?—Interesting history of the whale industry. (Whale Products Company, Seattle), 16 pp., 4 photos [advertising leaflet].

ZENKOVIČ, B. A. 1937—Weighing of whales. Comptes Rendus (Doklady) Acad. Sci. URSS, n. s., vol. 16, no. 3, pp. 177-182 [In English].

Breeding Habits of Captive Long-Tailed Weasels (*Mustela frenata*)

Philip L. Wright

Montana State University, Missoula

Introduction

Hamilton (1933) was the first American worker to maintain a number of weasels in captivity in order to study their life history. He kept several animals of two species (*Mustela frenata* and *M. erminea*) and obtained considerable information on the molt to white in the fall and the molt back to brown again in the spring. He raised litters of both species, born in captivity, and presented extensive data on the growth and development of the young. He obtained no matings but he did show that the gestation period in *M. frenata* is longer than the 42 days stated by earlier works to be the length of the period, since he had a female which produced a litter after being isolated for 70 days. Hall (1938) had a female *frenata* that produced a litter after 131 days without access to a male. In Europe Mallner (1931), Mathis and Psenner (1938), and Grigoriev (1938) presented evdience that the European stoat, *Mustela erminea*, had a long gestation period and in 1940 Watzka published an extensive paper on the stoat showing that the usual mating time was in June or July and that the young were born the following spring after a gestation period of 8 or 9 months.

The first live female of *M. frenata* which I obtained was taken in Minnesota in October 1937. This animal was caged alone after that time, and it produced a litter in the spring of 1938. The gestation period in this case was at least 130 days. In the summer of 1940 an adult male of *M. frenata* was caged with a female from July 20 until September 1 and on May 1, 1941 a litter was born. Thus the gestation period was at least 242 days. This record together with morphological data on the structure of the unimplanted blastocysts characteristic of the long period during which time the embryos are inactive was published the following year (Wright, 1942A). Lloyd McDowell, a student caring for my animals in my absence, observed copulation between two pairs of weasels on July 2, 1941. From this time on numerous animals have been bred each summer in my colony and it is the purpose of this paper to summarize the data so obtained. The animals were maintained as previously described (Wright, 42B).

General Nature of the Breeding Cycle

Data on various aspects of the reproductive cycle have been published (Wright, 1942A, 1942B, and 1947). Summarizing these papers briefly: a

This study has been aided by grants from the Elizabeth Thompson Science Fund and from the National Research Council Committee for Research in Problems of Sex.

single litter of young is born in the spring, usually in April. The young develop rapidly and at 3 months of age the females are full grown. The young males remain in a sexually immature condition during the first summer, but the young females as well as the parous females come into heat in mid-summer and are bred by the adult males. After a long period of quiescence lasting for several months, the embryos resulting from these matings become active in early spring and develop to term in less than 27 days after they become implanted. The adult males are sexually active from April into August.

ONSET OF HEAT

The period of heat is indicated by a swollen doughnut shaped vulva. The swelling is similar to that seen in estrous ferrets (Marshall, 1933) and in estrous martens (Enders and Leekley, 1941). The usual swollen vulva of the estrous weasel measures about 5 by 5 mm. (See Table 1). The maximum swelling seen was 7 by 7 mm., yet some females showed swellings no larger than 3 by 3 mm. Two animals with vulval swellings of 3 by 3 mm. and 3.5 by 3.5 mm. bred and produced litters. Pearson and Bassett (1944) found that the size of the vulval swelling in foxes is correlated with success of breeding. In those with large vulval size, there were more pups produced per mated female, there was greater survival of the young, and there were fewer animals which failed to whelp. I can see no evidence for this in *Mustela frenata,* though the data of Pearson and Bassett are much more extensive than mine.

Two female weasels born in captivity on May 1 were found to be in heat on August 19 and fertile matings ensued when they were bred shortly after this time. These animals were in heat when 111 days old. They may have reached estrus before this time as they were not examined earlier. Four females born in captivity on May 25 were first found to be in heat on August 26 at an age of 94 days. They were all bred then but no litters resulted. It is likely that the males used were no longer fertile this late in the season. A young female born on March 19 was found to show vulval swelling on June 9 at 82 days of age and was first bred on June 19.

Three young females born in the wild and apparently littermates were received from a trapper on July 2. They were not in heat when first examined but were in heat when next examined on July 30, August 6, and August 9.

The onset of estrus in young females is not accompanied by any visible change in the mammary glands, the nipples being invisible or scarcely visible. The nipples of parous females are conspicuous from several days before the birth of young in the spring until early summer. Regression continues after this time but the nipples can be seen throughout the summer and their presence serves to distinguish the adult females from the young.

Females which had borne young and had suckled them were first found to be in heat on 65, 69, 69, 70, 71, 77, 83, 86, and 104 days after the birth of young. Since lactation lasts for about 5 weeks, it is apparent that in this species there is no estrus during lactation as may occur in *Mustela erminea* (Deanesly, 1935). Females of *frenata* which had borne young but which had

not nursed them came in heat somewhat earlier on 36, 39, 46, 57, 58, 60, 67, 70, and 71 days after the birth of their litters.

Data from parous females caught in the wild during the spring and summer also indicate a considerable delay in the onset of estrus after the young are born. For example, a parous female that was no longer nursing taken in the wild on July 1 was not in heat at that time, but showed vulval swelling when next examined on July 31. Another parous female caught on July 1 was in heat on August 4. A third parous female caught on July 30 had blastocysts in the uterus of about 2 weeks development when one horn of the uterus was removed on August 2.

ONSET OF HEAT IN ANIMALS NOT BRED THE PREVIOUS YEAR

Watzka (1940) states that in *Mustela erminea* some animals breed in the summer and have a long gestation period, but others do not breed in the summer but come in heat in March. After mating at this time these animals are said to produce young after a gestation period of 2 months. Neither Deanesly (1935, 1942) nor Lavrov (1944) both of whom had larger numbers of specimens than did Watzka report evidence of this spring breeding and Deanesly (1942) states that animals bred in the spring "would include only a small minority of the females, which are non-pregnant at the end of the male breeding season." Lavrov (1944) says that as a rule all the females are impregnated in the summer.

In order to see if early spring mating could be obtained in *M. frenata,* three females were isolated during the breeding season in 1942 and then followed closely the next spring to see if they would come into heat earlier than if they had been bred the previous season. These animals came into heat on July 8, July 28, and August 12. After being bred at this time two of the three females produced young the following year after the usual long gestation period.

MATING BEHAVIOR

The majority of adult males have shown no interest in mating when placed with females in heat. Accordingly only a few males have been used for breeding purposes. Once a male has had breeding experience a mating can usually be obtained whenever he is caged with an estrous female. When a mating is to be made, the male is transfered from his cage to a box and then allowed to enter the runway of the female's cage. Usually he will sniff about the cage paying particular attention to the regions where she has urinated. The female remains within her nest box. Within a minute or two he moves toward the nest box and usually a scuffle ensues ending in the male grabbing the female by the scruff of the neck with his teeth. The resistance of the female to this procedure varies; some females make but a low chattering noise, others resisting for several minutes. If the female struggles vigorously the male will hold her by the neck until she becomes subdued. As soon as the female ceases struggling the male clasps her lower abdomen with his front feet and arches his back over her posterior regions. The actual insertion of the penis can not

be seen since the lower abdomen of the male is closely applied to the posterior part of the female's body. The two animals remain locked in this position for a long time, usually for about 2 hours, but sometimes for longer than 3 hours. Copulation in the ferret is also prolonged, the average duration being 2 hours (Hammond and Walton, 1934). At the end of coitus the female weasel usually becomes uneasy and attempts to break away. If the animals are left together copulation may take place again on the same day or upon succeeding days.

On several occasions females believed to be in heat from the appearance of the vulva have vigorously fought off the male so that no matings ensued. In some cases matings were obtained at later dates, but in a few no matings could be obtained during the whole breeding season. It often requires considerable effort on the part of the male to subdue the female before a copulation can occur. The fact that the male is larger, often weighing twice as much as the female, is certainly of considerable advantage to him in obtaining a mating. Usually the hold of the male on the female's neck does not draw blood. After copulation the attitude of the two animals toward each other varies considerably. Sometimes the male is not tolerated in the nest box and is kept in the runway by the female, sometimes the reverse situation occurs, and in other cases the two animals share the nest box without fighting. Only on one occasion has a male attempted to kill a female with which he was supposed to mate.

If on the day following the first mating the male is removed and another male which has been caged alone for several days is placed with the female a copulation will usually ensue at once, from which it appears that the female is still receptive when the male has lost the desire to mate. On the third day if the first male is replaced with the female, copulation may occur again. It is usually possible to obtain matings on three successive days and sometimes also on the fourth day, but I have seen no matings beyond this period. The above method of breeding has been used only for the past two seasons and it now appears that a larger proportion of females are successfully impregnated, than when one male is caged with the female throughout the breeding period. There is some evidence to be presented elsewhere that ovulation, which occurs only after mating, is delayed perhaps until the 3rd day after mating, in which case sperm from matings on the 2nd or 3rd days are probably more apt to fertilize the eggs than are those from mating on the first day. After mating the vulva regresses within a week or ten days to the anestrous condition. In this regard the weasel is like the ferret (Marshall, 1933) and unlike the marten (Enders and Leekley, 1941) in which the vulva does not regress until the end of the breeding season.

Once the female shows the swollen vulva she will remain in this condition for several weeks if not bred. I have not attempted to find the maximum length of time a female may be in heat and then be successfully mated. However, one female showed a swollen vulva on July 31, was first bred on August 17, and a litter was produced the next spring. Another showed a swollen vulva on July 28, was first bred on August 13, and a litter resulted.

GESTATION PERIOD

The available data on the length of the gestation period resulting from matings in captivity are summarized in Table 1. As can be seen, most of the matings occurred in July and August. There is great variation in the length of the gestation period even in different years in the same animal. Since the embryos reach the uterus as blastocysts about 2 weeks after mating (data to be published) and since the time from implantation to parturition is not longer than 27 days (Wright, 42B), the embryos could develop to full term in about 40 days if there were no delay in their development. The variation in the length of the gestation period, then, appears to be entirely an expression of the variation in the number of days the embryos are inactive in the uterus.

TABLE 1.—Data on matings in captivity resulting in the birth of young.

Number of female	Date first caged with male	Date separated from male	Number of male	Date young born	Length of gestation period	Size of vulva at breeding in mm.	Age of female at birth of young in years
17	7-20-40	9- 1-40	23	5- 4-41	285	?	2 ?*
30	7-15-42	7-18-42	50	6-17-43	337	?	3 ?
30	8-15-43	8-17-43	117	6-29-44	319	enlarged	4 ?
31	7- 2-41	7- 8-41	50	5-25-42	320	?	2 ?
31	8-20-42	8-26-42	50	5-23-43	276	6 x 5	3 ?
76	8-22-41	8-26-41	50	3-30-42	220	3.5 x 3.5	1
116	7- 8-44	7-12-44	117	2-24-45	232	6 x 5	4 ?
121	8-19-44	9- 1-44	117	5-25-45	278	5 x 4	3
122	8-15-43	8-17-43	117	6- 1-44	291	5 x 5	2
123	8-13-44	8-19-44	131	5-20-45	280	3 x 4	3
123	7-10-45	8- 1-45	117	2- 1-46	205	6 x 5	4
127	8-17-43	8-19-43	117	6-11-44	301	enlarged	2 ?
129	4- 1-44	4- 3-44	131	7-13-44	103**	4 x 4	1
129	9- 4-44	9- 5-44	117	4-21-45	229	5 x 4	2
129	7- 5-45	7-10-45	117	6- 6-46	336	5 x 5	3
130	8- 2-44	8- 4-44	117	4-18-45	260	5 x 4	2
130	7- 5-45	?	131	5- 6-46	305	5 x 4.5	3
132	7-31-43	8- 4-43	117	4-28-44	272	6 x 6	2
132	8-18-45	8-22-45	131	4-27-46	257	5 x 5	3
					Average 279 days		

* The question mark indicates that the animal's age is unknown. The figure given is the minimum age the animal could have.

** The gestation period of 103 days is excluded from the average. See the text for the reason.

The usual molt to white in the fall and the molt to brown in the spring occurs during the gestation period. It was previously shown (Wright, 42B) that the date of the onset of the spring molt is correlated with the date of the birth of the young, the former preceding the latter by about 47 days. In all but one of the 19 cases recorded in Table 1 at least a partial molt to white and molt to brown took place between breeding and parturition.

The short gestation period of 103 days given in the table would appear from the date of breeding and of parturition to be an example of the spring

breeding described by Watzka (1940) in *M. erminea.* This is not the case, however, as this animal had been exposed to modified light conditions prior to breeding and after mating underwent an incomplete molt to white in May, the usual time for the molt to white being in October or November. The record is included to show the extreme variation in the length of the gestation period which may occur in one animal, the periods being 103, 229, and 336 days. Since in almost all cases when the males were placed with the females copulation was seen to commence within a few minutes, the length of the gestation periods in Table 1 are calculated from the first day the two animals were caged together.

LITTER SIZE

In addition to the 19 litters resulting from matings in captivity, 15 other litters have been born from matings occurring in the wild before the females were captured. Early in this study the young were inspected soon after they were born to count them, but the mothers often became extremly excited and the procedure was discontinued. The mothers often eat the young after they die and as only a few young weasels have been raised to maturity, the average number of young from all 34 litters is not known. Several litters resulting from matings in the wild which were inspected soon after birth, had 6 to 9 young. The number of young from animals bred in captivity was often less.

FAILURE TO PRODUCE YOUNG AFTER BREEDING

In slightly less than half of the cases where females were bred in captivity, young were produced. Data obtained from bred females either by operation or from the death of the animal suggest that a considerable amount, at least, of the failure to produce litters is due to a failure of conception.

REFERENCES

DEANESLY, R. 1935—The reproductive processes of certain mammals.—Part IX. Growth and reproduction in the stoat. Phil. Trans. Roy. Soc. Lond. B, 225: 459-492.

———1942—Delayed implantation in the stoat (Mustela mustela). Nature 151: 365-366.

ENDERS, R. K. AND J. R. LEEKLEY 1941—Cyclic changes in the vulva of the marten (Martes americana). Anat. Rec. 79:1-5.

GRIGORIEV, N. D. 1938—On the reproduction of the stoat. Zoologischeskii Zhurnal 17:811-814.

HALL, E. R. 1938—Gestation period in the long-tailed weasel. Jour. Mammal. 19: 249-250.

HAMILTON, W. J., JR., 1933—The weasels of New York. Am. Midl. Nat. 14:289-344.

HAMMOND, J. AND A. WALTON 1934—Notes on ovulation and fertilization in the ferret. J. Exp. Biol. 11:307-319.

LAVROV, N. P. 1944—Biology of ermine reproduction (Mustela erminea L.). Trans.

Cen. Lab. of Biol. of Game Animals. People's Commisariat for Procurement, U.S.S.R. 6:124-149. (Only abstract seen)

MALLNER, F. 1931—Neues über die Roll- und Tragzeit der echten Marder. Folia Zool. hydrob. 2:145-163.

MARSHALL, F. H. A. 1933—Cyclical changes in the vagina and vulva of the ferret. Quart. Jour. Exp. Phys. 23:131-135.

MATHIS, J. AND H. PSENNER 1938—Beobachtung über die Tragzeit des Hermelins (Putorius ermineus L.). Anat. Anz. 85:292-299.

PEARSON, O. P. AND C. F. BASSETT 1944—Size of the vulva in the fox and its relation to fertility. Anat. Rec. 89:455-459.

WATZKA, M. 1940—Mikroscopisch-anatomische Untersuchungen über die Ranzzeit und Tragdauer des Hermelins (Putorius ermineus). Zeitschr. f. mikrosk.-anat. Forsch. 48:359-374.

WRIGHT, P. L. 1942A—Delayed implantation in the long-tailed weasel (Mustela frenata), the short-tailed weasel (Mustela cicognani), and the marten (Martes americana). Anat. Rec. 83:341-353.

———1942B—A correlation between the spring molt and spring changes in the sexual cycle in the weasel. J. Exp. Zool. 91:103-110.

———1947—The sexual cycle of the male long-tailed weasel (Mustela frenata). Jour. Mammal. 27:343-352.

Morphology of Hair of Eastern North American Bats

Eileen Sinclair Nason
Vassar College, Poughkeepsie, N. Y.

The hair structure of bats has been regarded as unusual by several authors, including Cole (1924), Mathiak (1938b), Williams (1938), and Hausman (1944). The writer made a study of hair structure of bats inhabiting eastern North America, giving attention to scale structure, presence or absence of a medulla, and differences (if any) between the two sexes and the young. Throughout the study, made on both tree and cave bats, the possibility was borne in mind that there might be some correlation between hair structure and tree and cave life; the taxonomic value of hair structure among the species studied was also investigated.

Two families, Vespertilionidae (16 species) and Molossidae (two species), were represented. Hamilton (1943:64-111) listed these bats and gave their approximate ranges within the eastern United States.

Technique

Museum skins of the 18 species of bats were used. To determine whether hairs, wherever found on the skin in a given species, had the same structure, hairs from different furred areas on a number of specimens in the genera *Myotis, Pipistrellus,* and *Lasiurus,* were examined microscopically. Since it was found that the scale structure was similar on various parts of the body in these species, hairs from all regions of the remaining species were not studied for it was assumed that hairs from the center of the mid-dorsal region would be typical for a species and be an adequate basis for comparing one with another.

A drop of xylol was placed on a microscope slide and a few hairs placed in the drop. The xylol served to hold such very fine hairs as these in place and also to clean them. The longer overhairs were then separated from the shorter underhairs by means of a needle and, by placing a ruler, calibrated in millimeters, under the slide, the total length of the hairs was easily measured. This has some advantage over placing xylol and hairs directly on a celluloid ruler. To measure the shaft diameters and the scale length (from the free distal edge of one scale to that of the next) a micrometer slide was used, being calibrated in 100 microns and 10 microns. As before, xylol was placed on the micrometer slide to keep the hairs reasonably stationary and to allow easy positioning of them by means of a dissecting needle or forceps. The slide was then examined by high power under a compound microscope. Both overhairs and underhairs from each species were measured.

To study pigmentation and scale structure, hairs were placed in xylol on a slide and a cover glass applied. Using high power magnification (10X ocular and 4 mm. objective) and a powerful transmitted light passing through a blue filter, the scales along the entire shaft length were examined. For

further reference, slides of hairs mounted in Canada balsam were made. As suggested by Cole (1924:117) for study of pigmentation in the cortex, the hairs were washed in a solution consisting of equal parts of alcohol and chloroform, then in xylol, and finally mounted in balsam. There was no noticeable advantage in using the alcohol-chloroform solution, since the lighting used was sufficient to allow shaft details to be observed when only xylol and balsam were used.

Cross-sections of hairs from each species were made by the method described by Mathiak (1938a). This consists of placing hairs on balsa wood coated with a celluloid solution and cutting with a razor blade. It is not easy to cut a good cross-section of a bat hair, which, being so fine, is difficult to place in the desired position. Mathiak's method is, however, quick and simple.

To confirm the presence or absence of structures believed to be observed in hairs mounted in xylol or in balsam, hairs were also pressed into a celluloid material used in cross-sectioning, and the solution allowed to harden. The hairs were then removed and the negative impression examined microscopically. In all instances the scale types observed were the same as before, although often in the impression the overlapping of two scales failed to appear, but this would seem to be due to an uneven distribution of pressure applied to the individual hair when placed in the celluloid. It must be rememberd that bat hairs are among the very finest of mammalian hairs, so that, in using methods of imbedding originally devised for much larger hairs, the results are not as satisfactory.

TERMINOLOGY

In referring to areas along the length of a hair, the following terminology is used: base, mid-region, widest or clublike part, and tip. The base and mid-region each occupy about one third of the length; the final third or less includes the clublike portion, from which the hair tapers to the tip.

The hair of the pelage of bats is of two types: overhair and underhair. Overhairs are distinguished by their greater length and shaft diameter. Often the latter is not noticeably greater than that of the underhair. Scale types include two: coronal and imbricate (Fig. 1). The coronal scale completely encircles the shaft. The distal edges of a coronal scale are often ridged or serrated, these variations being termed coronal serrate (Fig. 1, b, c) or coronal dentate (Fig. 1, d, e). The imbricate type of scale is characterized by not completely encircling the shaft. To encircle the shaft two or more small scales (hereafter called scalettes) are required and, by overlapping, the shaft is encircled. The free distal edges are not completely smooth and may be considered somewhat crenulated in the widest, or clublike, region of the shaft. There are five quite distinct types of imbricate scales. The longer elongate type (Fig. 1, f) is found on the parts of the shaft having the least diameters, as in the base, in the first part of the mid-region, and often in the extreme tip portion of a bat hair. An acuminate type (Fig. 1, g) apparently is not reported for any bat. Imbricate ovate scales (Fig. 1, h) are those whose transverse and longitudinal distances are about equal, at least when found in

the species studied. Ovate scales are usually found in the upper part of the mid-region, sometimes in the widest region, and in that portion of the hair where it begins to taper towards the tip. Imbricate crenate scales (Fig. 1, i) are found on the widest part of the hair shaft and in this type the transverse diameter is greater than the distance from the free distal edge of one scale to that of the next. The crenate scales do not have smooth free edges but are usually wavy or slightly ridged in outline. The imbricate flattened scale (Fig. 1, j) has a much greater transverse diameter than the distance between successive scales. This type was not found in the species examined.

While no medulla is present in hairs of any of the species examined in the present study, this structure is found in certain other bats such as some species of Pteropidae and Megadermidae which were studied by Cole (1924).

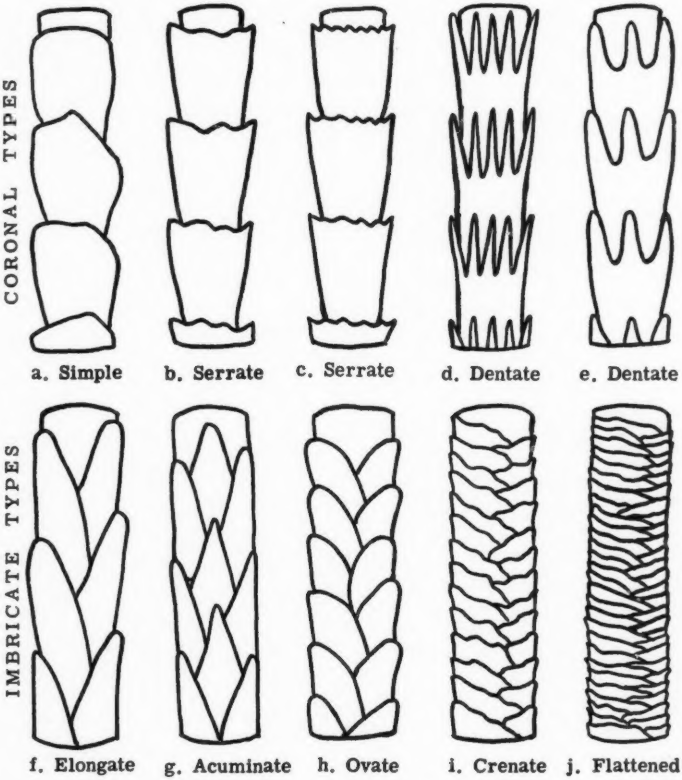


Fig. 1.—Main forms of cuticular scales in mammalian hair.

General Review of Hair Morphology

Formation.—Mammalian hair is a product of the epidermis. The hair shaft arises from the proliferation of the cells of a papilla which is situated in a flask-shaped depression in the epidermal layer. By rapid multiplication of cells of the papilla, the proliferated cells are extruded toward the follicle mouth. These cells form the layers of the root sheath and the structural elements of the hair shaft: the cortex, medulla, and cuticle. Pigment granules are found in the cortex and medulla but none are present in the cuticle, which is composed of thin, horny, transparent plates of keratinized protoplasm.

Hairs of mammals have a sufficient similarity to justify the belief that they all had a common phylogenetic origin. At first, the hairs were probably neither wholly sensory nor wholly protective in function. The protective function is obvious and there can be no doubt that highly specialized tactile hairs play an important part in sense perception. It seems probable that the earliest mammals or their immediate ancestors possessed cutaneous appendages related to the integumentary organs of several other classes of vertebrates. These appendages, having in generalized form many of the characteristics of hair, were then the primitive hairs from which the more or less diversified types now present have been evolved.

If it had been proved that hair is morphologically a scale or a sense organ, there would have been a firmer foundation on which to base studies of hair growth and function. There seems, however, to be no successful attempt to explain the phylogenetic origin of hair. As Danforth (1925:21) wrote: "For the present we must content ourselves with regarding mammalian hair as akin to lateral line organs, tactile organs of reptiles, placoid scales, teeth, claws, dermal scales and feathers. It is more closely related to some of these structures than to others, but with none of them is it fully homologous." The most acceptable view to Danforth seemed to be that of Botezat, who regarded hair as a structure which has no known antecedent in lower forms, that is, *sui generis*.

Cuticular scales.—The structural element of the hair shaft which is very prominent and characteristic of bat hair is the cuticle. Williams (1938:239) distinguished between overhairs of bats and those of insectivores from the observation that cuticular scales, which are obscure in hairs of insectivores, are very prominent in bats. For mammalian hairs the cuticle is described as a thin, unpigmented layer, composed of overlapping scales whose free distal edges are directed toward the tip of the hair. These scales interlock with the cuticle of the inner hair sheath, within the follicle. The scales of the sheath point in the opposite direction to those of the cuticular scales so that the hair is held securely.

Hausman (1930:5) wrote: "One of the most interesting and surprising relationships which came to be appreciated as the cuticular scales of the infrahominid mammals were studied was that, in general, the size of the scales (i. e., their antero-posterior width) and their forms varied together in a con-

stant way. Moreover, the size (and hence also the forms) of the scales bore a relationship, not to the species of mammal bearing the hair, but to the diameter of the hair shaft bearing the scales." The scales at the base of a hair are of greater longitudinal than transverse diameter, while nearer the tip the converse is true. Scale form and scale size appear to be the result of increasing of the diameter of the hair shaft which pulls out and flattens the cuticular scales proximo-distally. These differences in form seem to be due to the change in activities of the cells of the papilla and also to the gradual drying out of the shaft, and to wear on the free distal edges of the scales. Along the mid-region of the hair the scales are fairly uniform, which is due to the more or less uniform growth of the hair after it is once started.

Rudall (1941:13) wrote: "It is scarcely sufficient to regard the cuticle as an ornamental surface finish to the fibre, and a satisfactory knowledge of the cuticle should include its phylogenetic significance and an understanding of any part it plays in the physiology of the skin." In considering the phylogenetic aspect of the cuticle, he wrote (*ibid.*) as follows: "In the case of mammalian hair the cuticle cells occur at a position where separation of cell layers takes place. The hair, as it grows outwards from the body surface, is continually being separated from the wall of the follicle, and this cleavage takes place between the surface of the hair cuticle and the cuticle of the follicle wall." Rudall argued that this process is not unlike that whereby the reptilian scale is shed. Again, the separation of the hair filament from the follicle wall may be a possible function of the cuticle. Another function may be its binding effect which prevents the cortical layer from splitting, and thereby increasing the permanance of the hairy coat. The cuticle, too, may have served at one time in the process of evolution to prevent the transfer of water and soluble substances from the body to the outside.

Pigmentation.—Pigmentation of the cortex and medulla of hair is due to the deposition of melanin, formed by the action of tyrosinase upon tyrosine. There seems to be little doubt that pigment granules are produced *in situ* by the cells of the hair bulb. This pigment undergoes little change, so that apart from fading, the pigmentation of a hair may be considered the result of factors acting on hair-forming epithelial elements. There are distributional variations in pigmentation along the length of the same hair shaft, as the pigmentation at the basal portion may be very different from that of the middle portion, and that in turn from the pigmentation found at the hair tip. Variations such as these can be observed readily in the Red Bat (*Lasiurus borealis*), which has three distinct types of pigment distribution. The color of a hair depends upon the size of the pigment bodies and upon their numbers in the cortex or medulla.

Tapering.—Nearly all hairs are pointed at their tips and narrowed towards the root. This tapering is the result of the cell activities of the follicle. At the beginning and towards the end of a growth period, the activities of the cells and their numbers entering into the formation of the shaft are less than during the intermediate period.

DESCRIPTION OF THE SPECIES STUDIED

General description of the six species of Myotis examined.—The several species of *Myotis* are very similar in hair structure (Fig. 2, a) and coloring. All have imbricate scalation of the three types: elongate, ovate and crenate. Hairs of *Myotis grisescens* and *M. austroriparius* can be separated from the others by their short length and rather uniform pigmentation. *Myotis l. lucifugus, Myotis subulatus leibii, Myotis sodalis,* and *Myotis keenii septentrionalis* all have hair whose general pigmentation plan includes a black basal portion which becomes less dense in the mid-region, and a light brown terminal region. The dark pigments occupy three-fourths of the hair length. Among these species there may be slight variations in the degree of pigmentation and in the diameters of the shaft, but there is no definite distinction, as far as hair structure is concerned, to distinguish each species of *Myotis* with certainty.

The six species of *Myotis* studied are cave dwellers.

Myotis lucifugus lucifugus. Little Brown Bat.—The fur of the Little Brown Bat is medium in length and rather dense. The general color is rich brown. Microscopically there is observed to be a dense black pigmentation for three-fourths of the hair length. This gradually becomes a light yellowish brown and at the very tip there is little or no pigment. From a nursing juvenile, hairs were examined and the black pigment was already present. The hairs of the young bat were very short, but shaft diameters and scalation were like those of the adult hair. In hairs from the white areas of a "piebald" specimen no pigment was present throughout the entire hair and the scalation could easily be studied. Overhairs measure 9 to 10 mm. in length and underhairs 5 to 8 mm. See table (p. 358) for detailed measurements in microns.

Basal elongate scales are irregular (Fig. 2, a), that is, one scalette is usually placed higher than its component. In this way it can be certain that the imbricate scales are formed of two scalettes which overlap.

Myotis subulatus leibii. Leib's Bat.—The fur, of medium length, has a golden tint such as is present in the general brown color in the genus *Myotis*. The basal region is heavily pigmented with black and this extends for three-fourths of the hair length. This dense color gradually becomes less dense towards the widest region which is lightly pigmented and appears pale brownish. Pigments are concentrated in the region of the shart covered by the upper half of each scale in the basal and mid-regions (Fig. 3, a). Overhairs measure 10 mm. in length and underhairs 5 to 8 mm. Finer details with measurements in microns are shown in the table (p. 358).

Myotis grisescens. Gray Bat.—Both male and female have short medium gray-brown fur. This species is distinguished from others in the genus *Myotis* studied (except *M. austroriparius*) by its uniform pigmentation throughout the hair shaft. The young have more reddish pigment. This species has noticeably short hair in which the overhairs are very similar to the underhairs in length, and differing only in possibly having a slightly greater clublike area.

The hair length averages 6 to 8 mm. for both types. Measurements in microns are given in the table (p. 359).

Myotis sodalis. Pink Bat.—The fur is dull grayish brown and is of medium length. The dark region extends for three-fourths of the length, fading into a light grayish yellow. From the widest region to the tip a heavy brown pigment appears. Pigment is not as concentrated in the region of the shaft covered by the upper half of each scale as in *Myotis subulatus leibii*, but spreads more evenly throughout the shaft. Overhairs measure 10 mm. in length and underhairs 5 to 8 mm. Measurements in microns are given in the table (p. 359).

The crenate scales are noticeably even in this bat.

Myotis keenii septentrionalis. Eastern Long-eared Brown Bat.—This bat is similar to *Myotis lucifugus* in fur color. The fur is long and thick. As in most of the *Myotis* studied, there is dark pigmentation for three-fourths of the hair length, while the terminal portion has light brown pigmentation. Overhairs are very evident, measuring 10 to 11 mm. in length and underhairs 6 to 9 mm. For measurements in microns, see table (p. 359).

The crenate type of scale is not too evident, the ovate being the more common type in the widest region.

Myotis austroriparius. Rhoads' Bat.—The short, thick, wooly fur is drab brown or yellowish brown in color. The pigmentation is quite uniform, the tips being only slightly lighter in color. Medium brown pigments are present in the clublike region and from there to the tip a lighter brown color is found. Pigment is concentrated toward that region of the shaft covered by the distal half of each scale. Overhairs and underhairs measure from 5 to 8 mm. in length; shaft measurements, given in microns in the table (p. 359), are the same for both.

Lasionycteris noctivagans. Silver-haired Bat.—This species is a tree bat. Both male and female have long dark blackish-brown hair tipped with silver. For three-fourths of the shaft length there is heavy pigmentation. The final quarter is pigmented brown and the tip has very little or no pigment. The widest region has only a slightly brown pigmentation. The immature bat is much blacker in appearance than the adult, but has the prominent "silver" tip. Microscopically it was observed that the hair from the immature bat has a very short brown pigmented region. Their bases have heavier dark pigments than are present in the adult hair. Overhairs measure 10 mm. in length and underhairs 5 to 8 mm. Finer details with measurements in microns are given in the table (p. 359).

Pigment is concentrated in that part of the shaft covered by the distal half of each scale, except in the widest region where it is evenly distributed. The scale length of the basal and mid-regions is greater than that in most of the *Myotis* examined (see Fig. 2, b).

Pipistrellus subflavus. Pipistrelle.—The hair of this cave bat is medium in length and brownish-gray in color. The fur is really tricolored, that is, each

hair has a dark base, followed by a light yellowish-brown region for one-half the shaft length, and the tip is again black. Both sexes have similar fur color. July and November adults had the same hair color and structure. Hairs from a Kentucky specimen of typical *subflavus* could not be distinguished microscopically from hairs of a Massachusetts specimen of the race *obscurus* (whose pelage was duller and more yellowish), nor from hairs of a Pennsylvania specimen. Overhairs measure 10 mm. in length and underhairs 5 to 8 mm. Detailed measurements in microns are given in the table (p. 359).

The basal scales are quite regular (Fig. 2, c), and there is a transverse concentrated arrangement of pigment in the basal shaft region.

Eptesicus fuscus fuscus. Big Brown Bat.—The Big Brown or House Bat was probably, originally, a cave dweller. The fur is medium in length and of a uniform sepia-brown color. Both sexes are similar in hair color, but the fur of the young is much darker. A blackish-brown pigmentation with a reddish tinge present throughout the shaft was observed in a July juvenile. In the adult the black pigmentation extends for three-fifths of the hair length, followed by a less dense yellowish color. Specimens of the darker subspecies *osceola* were not examined. Overhairs measure 9 to 10 mm. in length and underhairs 5 to 8 mm. Finer details with measurements in microns are given in the table (p. 359).

The basal scales are irregularly placed on the shaft; the general scalation is very similar to that of *Myotis* (Fig. 2, a).

Lasiurus borealis borealis. Red Bat.—This is a tree species. The conspicuous, bright rusty color of its pelage distinguishes it from the other eastern North American species. The males have the brighter pelage of orange red, while the females have a duller buffy coat. The young resemble the female but have a deeper brownish color in their pelage. The interfemoral membrane is thickly furred. The shoulders of both sexes have a buffy white patch. The hair tips of the dorsum are frosted with white.

The bases of both overhairs and underhairs of adults are heavily pigmented with black, but the hair of the young has no black base. The black base extends for about one-quarter of the hair length. Next, to one-half the hair length, there is very little pigment present. As the shaft increases in diameter, a reddish pigment gradually concentrates and is present for the final quarter of the hair length. This reddish pigment is heaviest at the widest region of the shaft. Just before the extreme tip, which is frosted, the pigment is more blackish than red. In the young the hair is identical with that of the adult from the region on the hair where the red pigment first is present to the tip, but as the young hair has not reached its final length the absence of the black base is accounted for. The hairs of the interfemoral membrane are uniformly pigmented with red. Overhairs are present in both young and adult. The adult overhairs measure 10 to 12 mm. in length and those of the young 5 mm.; underhairs of the adult vary from 5 to 8 mm., those of the young 1 to 4 mm. Finer details (for adults) with measurements in microns are given in the table (p. 359).

The cuticular scales are of the usual imbricate types. There are no definite crenate scales as the scales in the widest region are not as flattened as in most species. The tip of the shaft has unusually long scales for this region and, since the proximo-distal diameter is much greater than the average shaft diameter, the scales here are imbricate elongate.

In the colorless or very slightly pigmented mid-region there is a "spiral" effect (Fig. 2, d). This can be found in the basal region, but due to the heavy pigmentation present the effect is not so evident. At first glance this "spiral" effect seems to be due to one scale completely surrounding the shaft (Fig. 2, d) but on further study there are found to be the usual two scalettes overlapping at the edges. One scalette is more prominent, overlapping the other so as to almost cover it. Finally, the effect is brought about by the higher position of one of the scalettes above the other, which is similar to the irregularly placed scalettes in the basal regions of such species as the *Myotis* studied and *Eptesicus fuscus*.

Lasiurus borealis seminola. Seminole Red Bat.—This tree bat is a darker reddish-brown than *Lasiurus b. borealis*. The fur is thick and long, and frosted at the tips. The interfemoral membrane is furred, the hairs being rusty throughout their length. Male and female have similar pelage color. The bases of the hairs are heavily pigmented with black for two-fifths of the hair length. For the next two-fifths there is light brown or little pigmentation. In the final fifth the red pigment predominates, the extreme tip being lightly pigmented. Overhairs are from 10 to 12 mm. long and underhairs vary from 6 to 9 mm. Detailed measurements in microns are given in the table (p. 360).

The scales are very similar to those of *Lasiurus b. borealis*. There is a "spiral" effect present but since there is more pigment present in this species it is not as apparent.

Lasiurus cinereus. Hoary Bat.—The pelage of this tree bat is yellowish-brown to dark mahogany, tipped with silver. The interfemoral membrane is furred. The coat has long, thick fur. For the first two-fifths of the hair length there is heavy dark pigmentation. The middle, for the next fifth, is only slightly pigmented, the pigment being concentrated transversely. The "spiral" effect can be seen in the mid-region but is not prominent. The last two-fifths of the hair, except for the tip, are heavily pigmented dark. Overhairs measure 10 to 11 mm. and underhairs 8 mm. For detailed measurements in microns, see the table (p. 360). Overhairs have a noticeably greater diameter in the widest region. Crenate scales are very distinct in the widest shaft region (Fig. 2, e). At the tip and the widest region the scales are very close together, presenting a "fir tree" outline.

Nycticeius humeralis. Twilight Bat.—This cave bat resembles the *Myotis* studied in hair color and scalation. It has short, sparse, dull brown fur. The hairs have a dark base and are light brown at the tip. Male and females have similar hair color. The dark region extends for three-fifths of the hair length, while the remainder has light brownish pigments. An April specimen and summer specimens examined had the same color appearance. Overhairs meas-

ure 10 mm. in length and underhairs 4 to 8 mm. See table (p. 360) for measurements in microns.

The basal scales are placed irregularly and the base has transverse concentrated pigmentation as in the *Myotis* studied.

Corynorhinus rafinesquii rafinesquii. Rafinesque's Big-eared Bat.—The general color of this cave bat is grayish-brown, being more brown than gray. Throughout the shaft there is rather uniform pigmentation. The dark pigments are more compact at the tip and mid-regions than at the base. There is no noticeable color difference between the male and the female. The fur is long, especially the underhairs which measure 7 to 9 mm. in length; the overhairs are 11 mm. long. See table (p. 360) for detailed measurements in microns.

The scales are slightly irregularly placed in the basal region but the scalation becomes more regular toward the tip (Fig. 2, f).

Corynorhinus macrotis. LeConte's Big-eared Bat.—This cave bat has the longest hair observed in the 18 species examined. Overhairs measure 12 to 15 mm. in length and underhairs 7 to 10 mm. The basal half of the length of the hair is dense black. The remainder is gradually more lightly pigmented, then densely pigmented, and finally, little or no pigment at the tip, which appears pale brown. This species is darker in color than *C. rafinesquii.* Detailed measurements in microns are given in the table (p. 360).

The crenate scales show irregular distal edges plainly (Fig. 2, f). In most of the shaft region the scales appear coronal at first glance because the pigment obscures the overlapping of the scalettes.

Dasypterus floridanus. Florida Yellow Bat.—Both sexes of this cave bat have long thick fur of yellowish-brown with a light reddish-brown tinge. The black base is followed by the slightly pigmented main region of yellow. The tip is black. The basal and mid-regions have a slight "spiral" appearance which is best observed in the yellow region. The tapering to the tip is not as gradual as in most bats, so that the scalation is seen clearly to the very tip. Overhairs measure 10 to 12 mm. in length and underhairs 7 to 9 mm. See the table (p. 360) for detailed measurements in microns.

Imbricate ovate is the predominant scale type. Some elongate scales are found in the basal and mid-regions but even here the ovate type is more common (Fig. 2, g).

Tadarida cynocephala. LeConte's Free-tailed Bat.—Both sexes of this cave bat have the same short, smoky, dull gray-brown fur with its short light-colored basal section. The main portion of the shaft is pigmented a medium dark color while the tip region is a dense brown. The hair is unusually short, all dorsal hairs averaging 4 to 6 mm. long, the longer being the overhairs which, in this bat, are not conspicuous by their average length but do have a slightly greater clublike region than the underhairs. Finer details with measurements in microns are given in the table (p. 360).

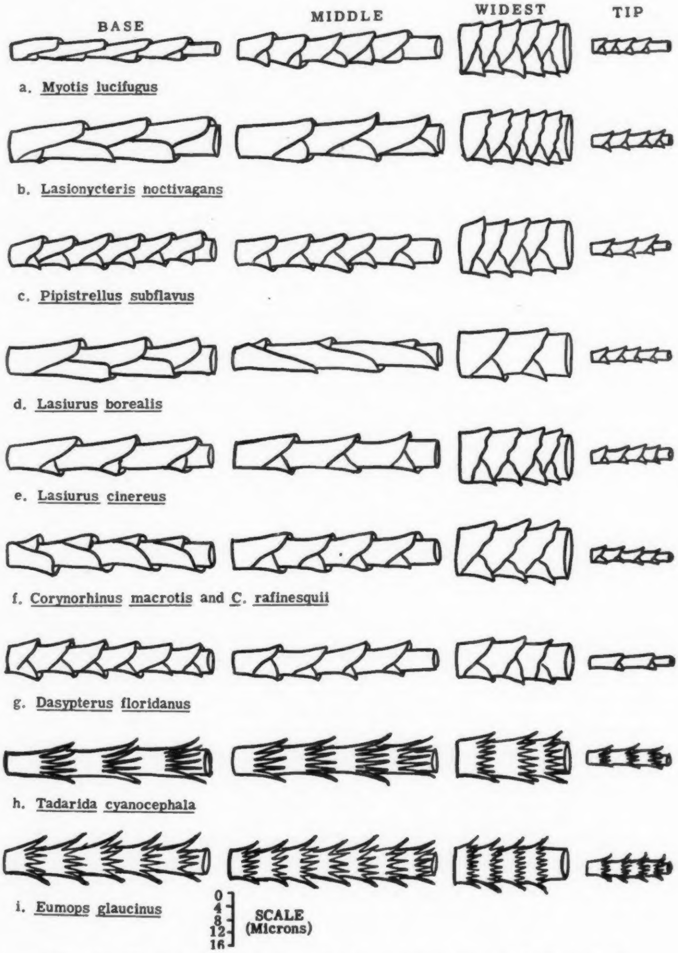


Fig. 2.—Typical scalation along the four main regions of the hair shaft.

The scales of this species are coronal and dentate throughout the hair length (Fig. 2, h). Each prong of the dentate edge measures 1 to 2 microns in width, and longitudinally each prong of the basal and mid-region measures 10 microns, while the scales at the widest and tip region have dentate prongs of 5 microns in length. There are about 10 of these prongs on each scale. Often in the basal and mid-regions some of the prongs are broken off. The pigment is distributed evenly in the shaft, but the region of the dentate prongs of each scale appears darker because of the irregular edge.

Eumops glaucinus. Mastiff Bat.—This species, which lives in hollow trees and cracks in cliffs, is apparently not common in North America. It has short brownish-black fur. The extreme base is colorless, followed by a pale brown pigmentation for one-fifth of the shaft length. The amount of pigment gradually increases so that three-fifths of the shaft has evenly distributed medium brown pigments, the final fifth being more densely pigmented with brown. In addition to resembling *Tadarida cynocephala* in size and color, the hair structure of this species is similar in that the scales are coronal and dentate (Fig. 2, i). The dentate prongs of the Mastiff Bat are not as long as those of *Tadarida*. These prongs measure 5 to 6 microns in length in the base and mid-regions and 3 microns in the widest and tip regions.

The overhairs are not too evident and measure 10 mm. in length, while the underhairs vary from 5 to 8 mm. There are no great variations in the diameter of the shaft and closely compacted scales combined, but the shaft alone is very small in comparison, as is seen when some of the prongs have been broken off. Detailed measurements are given in the table (p. 360).

The scales are very evenly applied to the shaft and are much closer together than in *Tadarida*. The scales (due to the prongs) expand at their distal region so that the general scale appearance is that of a funnel. The tip does not terminate as finely as in most bat hairs, but there is a tapering of the shaft which can be observed when some of the scales have been removed.

Discussion

The belief of such authors as Hausman and Mathiak is that the coronal scale is characteristic of such fine hairs as bat hairs. Hausman (1930:5) stated: "In the finest and softest hairs (i. e., those of least shaft diameter), one encounters only the coronal type of scales. . . . Upon shaft of hairs coarser than those of bats (those roughly above 8.5 microns in diameter) one finds almost exclusively the imbricate type of scales." Mathiak (1938b:263) described the hair of bats as: "Hairs without nodes and internodes, usually less than 20 microns in diameter. Medulla usually lacking. Scales mostly coronal, sometimes thickened and very prominent on some hairs."

The scalation and medulla are the two chief characteristics used in describing the differences between bat hairs and other mammalian hairs. It was believed by Hausman (1944:197) that the very finest hairs, as those of bats, are without a medulla. Some species of bats do possess a medulla, however,

such as members of the Families Pteropidae and Megadermidae which were studied by Cole (1924:118). In the 18 species examined in the present study, the medulla was never observed. There may be a question of evolution concerning the presence of a fragmented medulla or the complete absence of a medulla in very fine hairs.

Hereditary factors determine the basic characters of hair structure of any mammal. Environmental factors do influence hair structure but not to the extent of entirely altering the basic characters. Age, disease, and seasonal adjustments may each affect the normal condition of the hair. There did not seem to be any correlation between the hair structure of the bats studied and whether they live in trees or caves. The hairs of some of the *Myotis* species examined cannot be distinguished with certainty from the tree bat *Lasionycteris noctivagans*. Both have imbricate scalation of the usual types and similar pigmentation. This absence of correlation is not too surprising, since both tree and cave bats undoubtedly evolved from the same common ancestor.

Seasonal variations, as far as hair color and structure are concerned, do not seem very evident. The scalation is definitely not affected. Difference in pelage color between the two sexes is confined to only a few of the bats studied, being particularly noticeable in *Lasiurus b. borealis*. The very young of those species for which specimens were available, however, are usually of a different pelage color, often being much darker than the adults.

There is a certain amount of species difference in hair structure but this is not too great when one considers the 6 species of *Myotis* whose hair cannot be distinguished from that of *Eptesicus fuscus* or *Nycticeius humeralis*—except possibly by means of the pigment variations along the shaft. One can, however, distinguish hairs of *Lasiurus borealis* from those of the *Myotis* studied by observing the characteristic "spiral" effect in the mid-region of the hairs of the former. Both *Myotis* and *Lasiurus* can readily be separated from the hairs of *Tadarida cynocephala* because the latter has coronal scales which are quite unlike the imbricate types.

The distribution of pigment granules in the cortex of bat hair has no set plan. In the basal portion of hairs from the several species of *Myotis* and of *Eptesicus fuscus* and a few others, there is a transverse concentrated deposition of pigment, which when placed directly under the upper part of the scale, gives a circular coronal appearance to the scale. In another region, the pigments may be more evenly distributed along the shaft. In cross sections pigment granules appear as dots and are rather evenly distributed, if in the region of the transverse concentrated pigmentation of the base. Often, in the region adjacent to these concentrated areas, little or no pigment is seen. There seems to be a definite transverse arrangement of pigmentation in the basal portion of the shaft in some species of bats.

The corresponding shaft diameters in the bats studied showed relatively little variation, although the clublike region does show some, as it measures 15 to 18 microns in several species while in others it is only 12 microns. On

the whole, all diameters of the hairs of the bats examined remained within a range of 5 to 15 microns. The length of the hairs varies from about 4 mm. underhair to 12 mm. overhair. The usual underhair length is 5 to 8 mm. while the overhair length averages 10 to 11 mm. Overhairs are usually quite evident, except in *Myotis grisescens* and *M. austroriparius*.

In regions of heavy pigment it is difficult to see the overlapping of the imbricate scalettes. In the less pigmented regions the two scalettes can be distinguished, and in white hairs the overlapping of the farther side can also be seen. Of the 18 species examined, only two, *Tadarida cynocephala* and *Eumops glaucinus*, had coronal scalation, indicating that imbricate scales are the more common in the species studied.

Conclusions

1. This study adds support to Cole's findings (1924) that the hair structure of bats is of rather limited taxonomic value.
2. There is no noticeable correlation between hair structure and tree or cave life in the species studied.
3. The imbricate scale rather than the coronal scale is the common cuticular structure found in many species of eastern North American bats.

Acknowledgements

The writer is indebted to the following persons for the loan of specimens from collections in their charge: Prof. W. J. Hamilton, Jr., of Cornell University; Dr. H. H. T. Jackson, of the U. S. Fish and Wildlife Service, Washington, D. C.; Miss Barbara Lawrence, of the Museum of Comparative Zoology at Harvard; and Dr. R. S. Palmer, of Vassar College, for material from his private collection. I further wish to express my appreciation to Dr. Palmer for advice and assistance in directing this study; and to the Helen Gates Putnam Fund fellowship which made this study possible.

TABLE 1.—Hair measurements in microns and scale types.

Shaft region	Overhair diameter	Underhair diameter	Scale length	Scale type
		Myotis lucifugus lucifugus		
Base	5 (7 at scale edge)	5 (10 at scale edge)	14	Imbricate elongate
Mid	7 (10 at scale edge)	10	10	Imbricate ovate
Widest	15	13	5 to 7	Imbricate crenate
Tip	4	3	5	Imbricate ovate
		Myotis subulatus leibii		
Base	8 to 10	5 (10 at scale edge)	17	Imbricate elongate
Mid.	10	8 to 10	13	Imbricate elongate and ovate
Widest	14	10	6	Imbricate crenate
Tip	4	3	10	Imbricate elongate

TABLE 1.—(*Continued*)

Shaft region	Overhair diameter	Underhair diameter	Scale length	Scale type
		Myotis grisescens		
	(Overhair and underhair same)			
Base	7 to 10		15	Imbricate elongate
Mid.	8		12	Imbricate ovate
Widest	10		7	Imbricate ovate and crenate
Tip	4		8	Imbricate elongate
		Myotis sodalis		
Base	5 to 8	5 (10 at scale edge)	14	Imbricate elongate
Mid.	10	8 to 10	20	Imbricate elongate and ovate
Widest	15	11	5 to 6	Imbricate crenate
Tip	4	3	6 to 8	Imbricate ovate
		Myotis keenii septentrionalis		
Base	7 to 10	5 (10 at scale edge)	17	Imbricate elongate
Mid.	8 to 10	8 to 10	20	Imbricate elongate and ovate
Widest	18	14	5 to 7	Imbricate ovate and crenate
Tip	4	4	7	Imbricate ovate
		Myotis austroriparius		
	(Overhair and underhair same)			
Base	8 (10 at scale edge)		18	Imbricate elongate
Mid.	5 (8 at scale edge)		15	Imbricate elongate and ovate
Widest	10		7	Imbricate crenate
Tip	4		9	Imbricate elongate
		Lasionycteris noctivagans		
Base	8 (12 at scale edge)	8 to 10	18	Imbricate elongate
Mid.	10	8 to 10	20	Imbricate elongate and ovate
Widest	15	13 to 15	6 to 7	Imbricate crenate
Tip	4	4	7	Imbricate ovate
		Pipistrellus subflavus subflavus		
Base	5 (8 at scale edge)	5	10	Imbricate elongate
Mid.	8 (10 at scale edge)	8	11 to 14	Imbricate elongate and ovate
Widest	15	10 to 12	7	Imbricate crenate
Tip	4	3	7	Imbricate ovate
		Eptesicus fuscus fuscus		
Base	11	8	14	Imbricate elongate
Mid.	11	7 (10 at scale edge)	17 to 20	Imbricate elongate and ovate
Widest	17	15	9	Imbricate crenate
Tip	4	4	10	Imbricate elongate
		Lasiurus borealis borealis		
Base	7	5	20	Imbricate elongate
Mid.	8	8	20 to 25	Imbricate elongate
Widest	15	10	11 to 14	Imbricate ovate
Tip	4	3	15	Imbricate elongate

TABLE 1.—(*Continued*)

Shaft region	Overhair diameter	Underhair diameter	Scale length	Scale type
		Lasiurus borealis seminola		
Base	10 (12 at scale edge)	8	20	Imbricate elongate
Mid.	8 (10 at scale edge)	7	20	Imbricate elongate
Widest	18	12	14	Imbricate ovate
Tip	4	3	10	Imbricate elongate
		Lasiurus cinereus		
Base	5 to 8	8 to 10	20	Imbricate elongate
Mid.	8 to 10	8	20 to 25	Imbricate elongate and ovate
Widest	18 to 20	10 to 12	8	Imbricate crenate
Tip	4	3	6	Imbricate ovate
		Nycticeius humeralis		
Base	7 (10 at scale edge)	7 to 10	16	Imbricate elongate
Mid.	5 (9 at scale edge)	8	13	Imbricate elongate and ovate
Widest	12	11	10	Imbricate ovate and crenate
Tip	4	3	7	Imbricate ovate
		Corynorhinus rafinesquii rafinesquii		
Base	8 to 10	8 to 10	15	Imbricate elongate
Mid.	10	8 to 10	13 to 14	Imbricate elongate and ovate
Widest	16	14 to 15	10	Imbricate crenate
Tip	4	4	6	Imbricate ovate
		Corynorhinus macrotis		
Base	10	5 (10 at scale edge)	15	Imbricate elongate
Mid.	9	8 (10 at scale edge)	10	Imbricate ovate
Widest	18	10	7	Imbricate crenate
Tip	4	3	8	Imbricate ovate
		Dasypterus floridanus		
Base	8 to 10	8	10	Imbricate elongate and ovate
Mid.	7 to 9	8	14	Imbricate elongate and ovate
Widest	12	10	10	Imbricate ovate and crenate
Tip	4	3	11	Imbricate elongate
		Tadarida cynocephala		
Base	8	8	20	Coronal dentate
Mid.	8	5	16	same
Widest	12	10	12	same
Tip	4 to 2	4 to 2	9	same
		Eumops glaucinus		
Base	8	8	12 to 13	Coronal dentate
Mid.	10	9	9	same
Widest	12	10	7	same
Tip	2	2	7	same

REFERENCES

COLE, H. I. 1924—Taxonomic value of hair in Chiroptera. Phillipine Journ. Sci., 24(1):117-121, 2 pls.

DANFORTH, C. H. 1925—Hair with special reference to hypertrichosis. Chicago: Amer. Med. Assoc. 152 pp., illus.

HAMILTON, W. J., JR. 1943—The mammals o feastern United States. Ithaca, N. Y.: Comstock Pub. Co. v+423 pp., illus.

HAUSMAN, L. A. 1920—Structural characteristics of the hair of mammals. Amer. Nat., 54(635):496-523, 7 pls.

———1930—Recent studies of hair structure relationships. Sci. Monthly, 30(9):258-277, 19 figs.

———1944—The applied microscopy of hair. Ibid. 59(3:195-203, 4 figs.

MATHIAK, H. A. 1938a—A rapid method of cross-sectioning mammalian hairs. Journ. Wildlife Management, 2(3):162-164, 1 fig.

———1938b—A key to the hairs of mammals of southern Michigan. Ibid. 2(4):251-268, 38 figs.

MAXIMOW, A. A. AND W. BLOOM 1934—A text book of histology, 2nd ed. Philadelphia: W. B. Saunders. xiv+662 pp., 530 figs.

RUDALL, K. M. 1941—The structure of the hair cuticle. Proc. Leeds Philos. and Lit. Soc., sci. sect., 4, pt. 1:13-18, 2 pls.

STOVES, J. L. 1943—The biological significance of mammalian hair. Ibid., sci. sect., 4, pt. 2:84-86, 2 pls.

WILLIAMS, CECIL S. 1938—Aids to the identification of mole and shrew hairs with general comments on hair structure and hair determination. Journ. Wildlife Management, 2(4):239-250. 9 figs., 1 pl.

Census of a Population of the Red-Backed Salamander (Plethodon cinereus)*

Frederick H. Test
Department of Zoology, University of Michigan, Ann Arbor

Barbara A. Bingham
Detroit Zoological Park, Royal Oak, Michigan

Introduction

In 1944 the senior author censused a number of populations of the Red-backed Salamander (*Plethodon cinereus*) in the vicinity of Ann Arbor, Michigan. Some of the results from successive counts in the same area suggested that either there was considerable shifting of individuals, or that the methods used did not permit complete counts, or both. The study reported here was made in 1945 in an attempt to learn more concerning the usefulness of the census methods employed.

We are grateful to Professor Ralph L. Belknap for the opportunity to examine weather records for the period in which our study was made.

Description of Area

The woodlot in which this study was made lies about 4.5 miles west of Ann Arbor. It comprises an area of about 100 acres surrounded by farm land, mostly cultivated. The topography is gently rolling, with shallow ravines and basins in which water is present in the spring. Some big timber has been removed in the past, and a few large trees are cut every year at the present time.

The portion of the woodlot selected for censusing lies at one edge of the ungrazed and more heavily wooded part. It is a parallelogram with a small piece, roughly rectangular, left out of the southwest corner. The total area is 10,339 square meters (about 2.6 acres). Its southern end is bounded by a small streambed; all but a few yards of its west side is marked by a split rail fence separating the woods from a clover field; the north and east sides are continuous with similar parts of the woodlot. A small depression which held more or less water throughout the period of study lies near the middle of the east side. The land is highest along the northern boundary, sloping gently southward to the southern third of the plot, which was nearly level except in the southeast corner. The greatest difference in elevation is 4.4 meters.

The common trees in the census plot are sugar maple (*Acer saccharum*), white oak (*Quercus alba*), black oak (*Q. velutina*), red oak (*Q. rubra*), American hornbeam (*Carpinus caroliniana*), hickory (*Carya* spp.), beech (*Fagus grandifolia*), basswood (*Tilia americana*), and the flowering dogwood (*Cornus florida*). They range in size (DBH) up to 1 meter (white oak). A considerable variety of herbaceous plants common to such situations make a moderately heavy ground cover in the lower (south) end of the plot, a thinner

---

* Contribution from the Department of Zoology, University of Michigan.

cover in the north end. The north end of section A and the southeast corner of D contain scattered clumps of short grass.

The substrate is all underlaid by yellow clay. In most of the southern half of the census plot this was covered by 20 centimeters of loose, friable soil of high organic content and a continuous, but rather shallow, layer of litter, mostly leaves. Going upslope toward the north end, the organic layers become thinner, and at some points in section A the litter is lacking and clay is exposed. Here a high proportion of the non-living ground cover is composed of twigs, pieces of broken branches, and bark.

Few amphibian competitors of *P. cinereus* were found in the census plot. A few each of *Ambystoma jeffersonianum, Rana cantabrigensis, Hyla versicolor,* and *Bufo terrestris* were seen. Few known predators were found, although no special search was made for them. Reptiles apparently were entirely absent. Screech Owls (*Otus asio*) were not seen but probably were present. Migrant Olive-backed Thrushes (*Hylocichla ustulata*) were common for a period in May and early June, and the Wood Thrush (*Hylocichla mustelina*) probably nested in the woods.

The area of the census plot itself is little disturbed by man at the present time, although timber has been cut from it in the past, some apparently within the last five years. The nearest cutting in 1945 was about 25 meters east of the southeast corner of the plot. The only other fresh cutting nearby was about 80 meters north of the northeast corner. There is no indication of recent fire or grazing.

METHODS

The census plot was chosen and marked in early April, 1945, before the spring surge of plant growth. We had hoped to find a well-populated area bounded on three sides by barriers to movement of the salamanders, but such was not available. The area finally selected appeared to have a sizeable population of salamanders, but a reliable barrier (the clover field) was present along only one side and for only part of its length.

The census area was subdivided into four north-south strips (equal except for section A), and was marked by cloth streamers and white cord tied to the vegetation. This was done to help in censusing and as an aid in attempting to learn whether salamanders migrated into the plot from the adjacent woodland. The strips were lettered from west to east, A to D.

Around the ceusus plot, except for that part bounded by the clover field, was laid out a zone 23 meters wide. On April 19, and May 1, 8, and 21, a census of this peripheral zone was taken by the method worked out in 1944. The long intervals between counts were necessitated by unfavorable weather. The census could not be completed in the time available in a single day, and it was felt that the results for the different parts would be more comparable if made under similar weather conditions.

The census was taken by searching the area carefully and systematically for objects (logs, branches, stones, wood chips, bark, etc.) under which this species is known to occur. Each such object was lifted or overturned, the

ground or litter surface beneath was examined for salamanders and the object replaced in its original condition as nearly as possible. In an attempt to disturb the area as little as possible, logs were not torn apart nor did we dig in the ground or litter. A few large logs could not be moved by hand. These were left undisturbed, and any salamanders they harbored were uncounted. As each salamander was found, it was measured, its sex recorded, and released.

TABLE 1.—Dates and conditions of censuses

Census	Date	Temperatures (°C) Litter surface	Temperatures (°C) Beneath log	Sky	Moisture in litter
1	May 22	10.5	12	overcast	dry on top
	May 24	20	10	partly cloudy	dry on top
2	May 29	15.5	13	mostly overcast	wet except on top
	May 31	—	10.5	overcast	wet
	June 1	7–8.5	9.5	overcast	wet
3	June 5	11.5	9	partly cloudy	damp
	June 7	15.5	11	partly cloudy	dry on top
4	June 12	—	13	partly cloudy	dry on top
	June 14	—	17.5	fair	damp

The census plot itself was entirely searched four times, two half days usually being required to complete each census. Table 1 shows the dates, together with information on weather and the condition of the ground cover. All salamanders found on the census plot proper were removed to the laboratory and not replaced.

OCCUPATION OF COVERS

Numerous authors have said that *P. cinereus* is commonly found beneath a variety of objects on the forest floor, as well as in rotting logs. Rarely it is reported to occur beneath piles of decaying leaves, but a general distribution under the continuous cover of dead leaves on the ground has never been demonstrated.

Our experience in the vicinity of Ann Arbor has been similar. In the study area the principal covers were pieces of branches and logs lying on the ground. Chips of wood and pieces of sloughed bark were distinctly secondary in importance. Only a few salamanders were found beneath stones, for few stones were present and most of them were in the bed of the creek or sunk deep and tight in the ground. Two or three piles of small branches with leaves attached yielded a small number of salamanders. Because rotten logs were not torn apart, there is no record of the occupation of such situations.

Along with the census of salamanders, a count was also made of suitable cover objects on the area (Table 2). The judgment of "suitable" was based on considerable previous field experience with this species. All objects on the ground except branches less than about 15 millimeters in diameter, stones set tight in the ground, and the continuous cover of leaf litter were considered to be suitable.

There is great variation in size of the cover, most objects occupying an area of a few square inches, but a few covering areas of several square feet. A pile of wood chips or sticks, if affording shelter, was counted as a single cover. By far the greater number of salamanders was found singly, but covers sheltering two or more were not rare.

TABLE 2.—Occupation of covers

Units	Logs and branches <3" diam.	Logs and branches >3" diam.	Bark, chips	Others	Totals and averages
Peripheral zone					
Covers present					2883
Covers occupied					4.2%
Census Plot					
Covers present	2256	157	460	14	2887
Covers occupied					
Census 1	3.2%	18.5%	2.4%	0.0%	3.1%
Census 2	3.3%	28.0%	3.3%	21.4%	4.5%
Census 3	2.3%	24.8%	4.1%	14.3%	3.9%
Census 4	1.7%	17.8%	4.6%	42.8%	3.6%

In the peripheral zone there were 2883 covers, excluding 10 logs which were too large to examine without greatly disturbing the area. Of those 2883 covers, 4.2 per cent were occupied. In the census plot, the first count showed 3.1 per cent of the 2887 covers to be occupied. There were 7 immovable covers. On succeeding censuses, 4.5, 3.9, and 3.6 per cent of the covers were occupied. It is clear from these data that, at the time studied, less than 5 per cent of the available covers in this area were occupied by red-backs on the surface of the ground. The much greater occupancy of large covers in contrast to small ones probably results from the more common occurrence of underground retreats opening to the surface beneath the former.

SIZE OF POPULATION

The number of salamanders found in each section at each census is shown in Table 3. The total taken from the plot was 496, an average of one salamander for each 21 square meters. The most striking thing shown here is the fact that the number obtained in succeeding censuses remained high—although there was a progressive decrease after the second census. Even after four removals, there still were salamanders on the area, as a subsequent visit showed.

The question arises: Where were the salamanders, taken in the later censuses, at the time of the early searches? Two important possibilities present themselves: (1) that they migrated into the area after the original removal; (2) that they were hidden on the area in unsearched places.

Let us examine the first of these possibilities. Almost nothing has been published concerning spatial movements of individual *Plethodon cinereus*. *Plethodon cinereus* has rarely been seen active away from cover, but it has been suggested that females may congregate at suitable breeding sites in the

summer. (See Test, 1946, for a summary of published observations.) The senior writer once followed some movements of a large female which was naturally marked by unpigmented areas of skin. On October 2 she was found beneath a small piece of wood. When released under it after being examined, she left and moved rapidly across the surface of the dead leaves on the ground to a larger cover 63 centimeters away. On October 5 she was back where first found. The next day a search of the area failed to reveal her, but on October 20 she was under a cover 1.8 meters from the original one. Another search on November 1 did not locate her. Thus in about three weeks she had made at least two moves but was still near the place where first found. Like many higher vertebrates, individuals of *P. cinereus* may have home ranges.

TABLE 3.—Distribution of sample among sections of census plot

Sections	Census 1	Census 2	Census 3	Census 4	Totals
A	40 (33.9%)	35 (23.9%)	35 (26.7%)	25 (24.8%)	135 (37.2%)
B	12 (10.2%)	22 (15.1%)	27 (20.6%)	20 (19.8%)	81 (16.3%)
C	22 (18.6%)	36 (24.7%)	30 (22.9%)	25 (24.7%)	113 (22.8%)
D	44 (37.3%)	53 (36.3%)	39 (29.8%)	31 (30.7%)	167 (33.7%)
Totals	118 (100.0%)	146 (100.0%)	131 (100.0%)	101 (100.0%)	496 (100.0%)

Kline and Fuller (1932) have published data showing that some semi-aquatic species, such as *Gyrinophilus porphyriticus* and *Desmognathus fuscus*, may move upstream as much as 30 feet in one day, and even farther downstream. Their data also show that at least one individual had a home range in the stream and spring at its head. Because of the greater uniformity of favorable conditions in the water, more extensive movement would be expected there than on the surface of the ground, where conditions of humidity and light would strongly limit it. These authors believed that the two species mentioned above wandered at night on the surface of the ground as much as 19.5 meters from springs, but they gave no evidence that all this movement was above ground nor in one night. It seems probable that the salamanders may have come to the ground surface at some distance from water by using burrows and then moved about within a small radius of such shelter. Such movement is suggested by Wilder's studies (1913) on *Desmognathus fuscus*.

If our salamanders moved about extensively on the surface of the ground, one would expect available types of covers to be occupied in about the same proportion in each census. Actually, the number of small covers occupied fell off 47 per cent between the first and last censuses, whereas the number of occupied large covers dropped less than 4 per cent. Rains were unusually frequent, resulting in sufficient moisture in the soil and leaf litter throughout the census period to prevent a significant differential in moisture between large and small covers, although in long periods of dry summer weather the small covers dry out much faster than the large ones.

It is possible that a difference in air temperature between the first and last censuses is an important factor in the drop in occupancy of small covers, for the temperature beneath small covers probably approaches the outside

temperature more closely than does that beneath large ones. Unfortunately, this cannot be known, for records of temperature at the surface of the leaf litter were omitted on the last census, and none at all were taken beneath small covers.

We believe that the most important difference between the large and small covers, in the census period, was the presence of surface openings of large earthworm tunnels and burrows of small mammals beneath a very much greater proportion of the large covers. These, we believe, are refuges for large numbers of *P. cinereus*. Several times we have found individuals actually in such tunnels, and on various occasions salamanders have escaped us by quickly moving into them. Cochran, too, has found red-backs in burrows below the surface of the ground. Underground burrows are known to be used more or less by other species of salamanders, including some plethodontids. Kline and Fuller believed, with some evidence to support it, that a large proportion of the semi-aquatic salamanders they studied were underground at any given time.

From what has been given above, we conclude that there probably was only a small amount of shifting of individuals in the course of the study and that a very large part of the population is elsewhere than directly beneath cover, probably mostly underground. Some may have been in rotten logs, although there were few of these on the area. We conclude also that it would require a considerable amount of intensive collecting to remove all the red-backs from any area which is at least moderately well populated. We are inclined to believe that Burger's statement (1935) that ". . . in collecting *P. cinereus*, one is not so likely to skim the surface of the population, as Kline and Fuller (1932) found to be the case with Desmognathus," may need modification.

COLOR RATIOS

Of the 496 salamanders taken within the census plot, data on coloration are available for 451. Of these 65.4 per cent had a dorsal stripe; the rest were of the phase in which the dorsum is entirely black. In the sample of 128 from the censused peripheral zone, the color ratio was similar, 63.3 per cent being striped individuals.

Comparison of the four counts on the census plot shows a high degree of similarity, the striped phase always being more common than the black. The range of variation is 10 per cent (61.2 - 71.2 for the striped phase). It will be noted that the value of the color ratio for the peripheral zone falls within this range. On the basis of these five samples, which ranged in size from 101 to 132, it may be concluded that a sample of about 100 individuals is large enough to show, within fairly narrow limits, the relative proportions of the color phases present under covers in the sampled area, in the spring. With all observed salamanders being removed in each census, the fact that there is no trend of change through the four censuses of the plot suggests that these samples show the proportions actually present everywhere in the censused area, unless there is a differential response to environmental conditions. Using the totals for all censused areas (Table 4) it is evident that there is no differ-

ence between the sexes in color ratio. Comparison of immatures with adults shows a small, but probably insignificant, difference.

TABLE 4.—Proportions of the color phases in the entire censused area (peripheral zone + census plot)

Color phases	Males	Females	Unsexed imm.	Totals
Black	31.9% (72)	32.8% (19)	38.0% (112)	35.1% (203)
Striped	68.1% (154)	67.2% (39)	62.0% (183)	64.9% (376)
Totals	100.0% (226)	100.0% (58)	100.0% (295)	100.0% (579)

On the basis of this similarity in color ratio of all groups in the population, we may examine the various samples for amount of variation with small samples. They show remarkably little variation. With the 13 usable samples ranging in size from 11 to 72, the variation in proportion of striped salamanders is only 19.7 per cent (54.5 - 74.2).

Of all the 579 salamanders from the census plot and peripheral zone together, 64.9 per cent were of the striped phase. In most of these the stripe was of the usual red color, commonly more or less mottled with black. However, six (1.04 per cent of the total sample) had dorsal stripes which were distinctly yellow. Single examples of two other color variants were found. One had a pink dorsal stripe. The other had a stripe which was unpigmented except for a small amount of black mottling.

SIZE GROUPS

Blanchard (1928) found that individuals of *P. cinereus* become mature at 35-38 millimeters, head and body length. The senior writer's experience has been similar, and his data (unpublished) indicate that a length of 34 millimeters will separate most of the sexually mature, striped individuals from the immatures. It seems to be a better separation for males than for females. This measurement is taken from the tip of snout to anterior side of base of hind leg. Blanchard measured to the posterior side.

On the basis of this criterion, the entire sample collected had 284 adults and 295 immatures, a ratio of 49 per cent to 51 per cent (Table 5). Between the two color phases there is a difference of 6.4 percent, adults forming 44.9 per cent of the unstriped phase and 51.3 per cent of the striped. This difference is not statistically significant, but the matter should be studied further, for it would be of considerable importance if a smaller percentage of the unstriped phase should be found to reach sexual maturity. It is this phase which was less common in the population. It is possible, on the other hand, that the black phase never grows as large as the striped one and reaches sexual maturity at a smaller size. We know of no data on these points. The four samples taken from the census plot showed a variation in number of adults from 56.6 per cent to 48.0 per cent, with a gradual diminution from the first to the last. The single sample from the peripheral zone, taken before those from the census plot, had the lowest proportion of adults, 43.8 per cent.

TABLE 5.—Age and sex groups

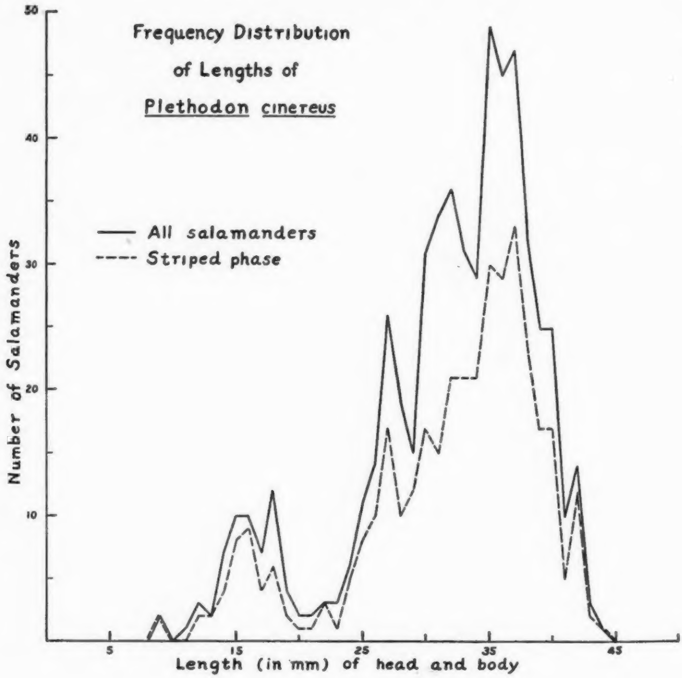
Units	Sexes of adults Males	Females	Ages Adults	Immatures
Peripheral zone	58.9%	41.1%	43.8% (56)	56.2% (72)
Census plot	76.9%	23.1%	50.6% (228)	49.4% (223)
Census 1	72.3%	27.7%	56.6% (65)	43.4% (50)
Census 2	79.5%	20.5%	54.6% (78)	45.4% (65)
Census 3	78.3%	21.7%	51.7% (60)	48.3% (56)
Census 4	77.1%	22.9%	48.0% (48)	52.0% (52)
Total* sample	73.6%	26.4%	49.0% (284)	51.0% (295)
Black	79.1%	20.9%	44.9% (91)	55.1% (112)
Striped	79.8%	20.2%	51.3% (193)	48.7% (183)

* Includes individuals for which no color data are available.

Figures derived from Blanchard's chart (*loc. cit*., p. 160) of size groups in *P. cinereus* collected in October and November show a total of 196 specimens. These comprise five collections, but it is not clear how many populations are represented. However, 58.7 per cent of these were adult on the basis of a size criterion similar to that used for our own figures. This is rather surprising, for most, at least, of the young are hatched in late summer, from which a considerably higher proportion of immatures would be expected in the fall. Either there is little or no differential in mortality between adults and immatures through fall and winter, or the small young keep well hidden in the autumn.

Plotting frequencies of the size classes (head and trunk length) for the 566 of our total sample for which this datum is available, produces a curve (Figure 1) somewhat different from that of Blanchard's. Because of a difference in the points used in measuring, it is necessary to subtract 2 millimeters from each of Blanchard's measurements to make the two sets of data comparable. When that is done, Blanchard's curve shows distinct peaks at 15, 28 and 41 millimeters. Our curve shows three significant peaks also, and two more which may or may not indicate age groups. The most obvious peaks are at 18 and 35 millimeters. During the summer, members of these two groups presumably would grow, respectively, about 10 and 6 millimeters, on the average, to reach the sizes shown by Blanchard's autumn specimens.

Our two individuals at 9 millimeters may have been hatched that same spring, not long before the date (May 22) on which they were found. Piersol (1910) says that the young hatch at a total length of 20-25 millimeters, and his figure of this stage shows the head and body length, as measured by us, to be 11 - 14 millimeters. Bishop (1941) indicates slightly smaller measurements. Piersol believed that young "slightly larger" than the size at hatching, found in May, were hatched in the previous fall. This may be true for our very small specimens, though they are smaller, not larger, than the hatching size given by him. The extended breeding season (Blanchard, 1928) and long period of development in the egg suggest that young may sometimes hatch in



the spring. Sherwood (1895), in fact, records finding a bunch of eggs in late October.

It is probable that the peaks at 27 and 32 millimeters would not be apparent in a larger sample, although they may possibly represent different age groups.

A plot of the striped salamanders alone looks much like that for all individuals. It is found, too, that they form practically the same proportions of each of the two principal size groups, these proportions being 65.5 and 64.8 per cent.

SEX RATIO IN ADULTS

The sex ratios here given (Table 5) are based almost entirely on external examination, in which the region of the naso-labial groove was used as the principal indicator of sex. Sexing of salamanders from the peripheral zone was done in the field by both of us. The others were sexed in the laboratory by the junior author. A check on the accuracy of this method showed that the

senior author had a sexing error of 7.3 per cent (4.7 for males, 11.1 for females). The junior author's sexing error was 9.8 per cent (15.2 for males, 7.3 for females). These errors approximately cancel each other for the peripheral zone, but the proportions of males given for the census plot (sexed only by the junior author) may be as much as 8 per cent too low.

On the census plot, the salamanders found were predominantly (76.9 per cent) males. If corrected for the sexing error noted above, this figure would be about 85 per cent. The variation in successive censuses was not large, proportions of males ranging from 72.3 to 79.5 per cent. The census of the peripheral zone revealed a considerably lower percentage (58.9) of males. It is highly probable that the sex ratio found on the census plot is not representative of the ratio actually present there. Rather, it is probably an indication of a sexual difference in habits. Blanchard has indicated that the eggs are laid in early June. At the time of our census the females probably were retiring to nesting sites underground or in logs — situations not sampled by our method of censusing. In contrast, much of the study of the peripheral zone was made earlier, while some mating may well have been in progress and each sex actively in search of the other.

Blanchard's figures for 348 *P. cinereus* of all ages collected in the breeding seasons, both spring and fall, near Ann Arbor show 54.9 per cent males, with the proportion almost exactly the same for the two main color phases. Burger (1935) says that the sex ratio of adults is 1:1, without giving any data.

The striped and black color phases of our sample show similar sex ratios, the external sexing indicating 78.9 and 75.7 per cent males, respectively, on the census plot. In the peripheral zone the percentages were 59.0 and 58.8, respectively.

SUMMARY

Four censuses of the Red-backed Salamander (*Plethodon cinereus*) were made between May 22 and June 14, 1945, on an area of about 10,000 square meters in a hardwood woodlot in southern Michigan. The number of individuals removed totaled 496, successive censuses producing 118, 146, 131, and 101. There are indications that a large part of the salamanders taken after the first census were on the area previously, and that migration had little effect on the samples. The striped phase comprised 65.4 per cent of the population (range of single censuses, 61.2 - 71.2). A similar proportion appeared in both sexes and the two principal size groups. Three other color variants formed less than 1.5 per cent of the population. Adults and immatures were represented about equally. Among adults, males formed three-quarters of the sample, females probably being better hidden rather than less abundant. Less than 5 per cent of the apparently available covers were occupied by salamanders at any one time.

A single, preliminary census of an area of about the same size, adjacent to the boundaries of the census plot, gave statistics similar to those for the census plot. An exception was the sex ratio, which showed about 59 per cent males.

REFERENCES

BISHOP, S. C. 1941—The salamanders of New York. New York State Mus. Bull., No. 324, 365 pp.

BLANCHARD, F. N. 1928—Topics from the life history and habits of the Red-backed Salamander in southern Michigan. Amer. Nat., 62:156-164.

BURGER, J. W. 1935—Plethodon cinereus (Green) in eastern Pennsylvania and New Jersey. Amer. Nat., 69:578-586.

COCHRAN, M. E. 1911—The biology of the Red-backed Salamander. (Plethodon cinereus erythronotus Green). Biol. Bull., 20:332-349.

KLINE, E. K. AND N. M. FULLER 1932—Interpretation of laboratory findings in rural spring water supplies. Amer. Jour. Pub. Health, 22:691-699.

PIERSOL, W. H. 1910—The habits and larval state of Plethodon cinereus erythronotus. Trans. Canad. Institute, 8:469-493.

SHERWOOD, W. L. 1895—The salamanders found in the vicinity of New York City, with notes upon extra-limital or allied species. Abstr. Proc. Linn. Soc. New York, 7:21-37.

TEST, F. H. 1946—Relations of the Red-backed Salamander (Plethodon cinereus) to light and contact. Ecol., 27:246-254.

WILDER, I. W. 1913—The life history of Desmognathus fusca. Biol. Bull., 24:251-342.

Sharks, Sawfishes, and Rays: Their Folklore

J. L. Baughman
Texas Game, Fish and Oyster Commission, Rockport

The old Hawaiian kings preferred to use human bait for sharks. It was cheaper than pigs, and just as acceptable to the sharks. Nevertheless, most sharks are not man-eaters. However, ever since the time of earliest man, sharks, sawfishes and rays have exercised as great a fascination upon the popular imagination as do the lions and tigers of the land. The idea that a fish might be large enough, or strong enough, or well enough armed, to hunt, or injure or destroy man, the mighty, has always been a never ending source of comment. The result is that a vast folklore has grown up about these fishes; a folklore from every sea and every land; tales that have had their inception with men as widely apart as a primitive islander of Torres Strait and a cultured author of the western world; tales that reach from the beginning of time down till now.

Oppian, in sonorous Greek, sings of the blue shark, Glaucus, "which loves its young beyond all other fishes." It and other species of sharks were supposed to offer their young a refuge in time of trouble, taking them into their mouths or wombs to hide, and ejecting them again, once the danger was passed. Pliny (who makes the profound statement that there are no less than 74 species of fish) is our authority for the story that the sponge divers of the Mediterranean were often attacked by dogfish, which occurred in "clouds" or schools. Moreover, he gives at some length the medicinal properties of the torpedo, detailing among other things, a large number of remedies that could be prepared from this fish, all of which could be used as specifics for many of the ills of the human race.

In more recent times sailors of the Caucasian races, equally as credulous as the Greeks or Romans, perpetuated upon the world another fable, that of the swordfish and thresher shark acting in collusion to destroy a whale. The fallacy of this belief was shown by Townsend (1929), but that such a denial should be necessary at that date shows the persistence of such folk tales, even among civilized peoples.

Among the Bavili, a West African tribe living about the mouth of the Congo, sharks have a semi-religious significance, and *Nquimbike Ku Vuka,* the shark that devours, is represented by a fin placed in the *xibila* or sacred grove (Dennet, 1907).

In the New World, among the southern Amerindians, references to any of the elasmobranchs are not numerous. In northern Honduras, Gann (1900) unearthed the pottery image of a shark, and he states (1912) that about Santa Rita (where pottery figurines of animals, with human heads projecting

from their widely opened jaws, are common) sharks were evidently favorite models. Shark's teeth have been found in the ruins of Holmul, Guatemala, as have stingray spines. These latter were probably used in religious ceremonies (Tozzer, 1941), and have also been unearthed at Uaxactun (Smith, 1932).

There is no evidence that any of these objects were of religious significance themselves. However, like many primitive peoples, the Mayas occasionally identified their Gods with some animal, fish, or bird; and in the Tizimin MS there is mention of *Chac-uyab-xoc,* the red, or great demon shark, while Roys (Tozzer, 1941) states that he would like to construe the *Ah-kak-nexoi* of de Landa to mean rather *Ah-kak-ne-xoc,* thus giving the fisherman's god a name meaning "fire-tailed shark." Among the modern Maya no folk tales concerning the elasmobranchs have been reported, but among their successors on the Honduran coast, i.e., the Miskito, the children of the tribe play a game which is entitled *"ilili pulaya" or* "playing at shark." The game is played in the water, and the boy who is "it" represents the shark. He stealthily dives among the others, and pinches or bites them under water. This is a favorite game, which fun and fear combine to make very exciting (Bell, 1899).

Among the Tlingit Indians of northeastern America *"Tus hit!"* and *"Q! á tqu hit,"* both meaning "shark house," were names of two of the subdivisions of the tribe, while the chief of still a third rejoiced in the name of *"Ha yeak!",* the Indian term for the hollow left in shallow water by a rapidly swimming shark. The carved emblem of the *Nanyaá yî* and *Ka glwantan* clans was a shark crest, accompanied, in the case of *Ka glwantans,* by face painting representing the devilfish. Such crests were utilized in shows put on at tribal gatherings or potlaches. Gambling sticks used by the tribe instead of our more modern (?) dice, were named after various animals, and among these was one known as *tus,* the Tlingit word for shark. This tribe called another elasmobranch, a skate, "the canoe of the land otter." (Swanton, 1908).

In South America, while there are doubtless others, I have found few evidences of elasmobranchs in folklore. However, Roth (1915) has collected several tales from among the Guiana Indians wherein various members of the family occur. Among the Warrau there is a tale wherein the under-water people, or Oriyu, keep sharks as humans keep dogs. Moreover, with a view to their becoming good hunting dogs, this tribe names their canine friends after those animals which are known to hunt well, among them the shark.

Dance (1881), in the story of *Nohi-Abassi,* another Warrau tale, induces a shark to eat up his mother-in-law, thus relieving him from a hateful bondage. However, he was caught and his leg cut off by his sister-in-law in revenge for her mother's death. Today Nohi-bassu, his wife, and leg, may be seen among the stars, he as the constellation known as the Hyades, the missing leg as Orion's Belt, while his wife is represented by the Seven Sisters of our Plains Indians, the Pleiades of the Greeks.

Interesting as these cases may be, they are isolated occurrences when we

compare them with the great mass of material from the peoples of the southern and western Pacific.

Among the Gilbert Islanders one of their tutelary deities, *Tabaruaki,* occasionally assumed the form of a shark, *Nei de Tuahine* was a goddess who lived in the sea and swam about in the form of a sting-ray, while *Taufa* of the sea, a deity of the Tongans, often appeared to his worshippers in the form of a shark (Frazer, 1913-24).

The Marquesan tribe known as the Houmas, considered the sting-ray tabu. Not only would they not eat of the flesh, but they fled in horror if it was shown to them. Moso, of Samoa, was one of the gods of the land, as opposed to *Tangaloa,* god of the heavens, and was in some families, the household god, incarnated in the form of a stingray (Turner, 1884). These *aitu,* or household gods, were among the most numerous of the Samoan deities, and occasionally, when their worship was extended to an entire district, were the cause of serious trouble. For instance, if people who had a stingray or shark as their local object of reverence heard that their neighbors had caught a fish of that sort, they would go there in a body and beg them not to cook and eat it. Should they be refused their bequest, a fight ensued for the protection of the god. Such beliefs were also common to the Marshall and Peleu islands.

Offerings were sometimes made to these *aitu.* In Ponape the *Tipenway* clan, whose totem was the stingray—whenever they found one stranded on the shore—were careful to replace it in the water, and formerly, when a member of the clan died, his friends used to pour coconut milk on the waters, perhaps because they thought that the soul of the deceased had taken up its abode in one of these fish.

Such beliefs, i.e., the transmigration of souls to the bodies or shark or rays, were not uncommon.

At Saa, in the Solomon Islands, the ghosts of the dead are believed to inhabit various animals, among them sharks. Dying people frequently announce their intention of becoming one of these fish when they have put off their human shape; and if any shark remarkable for its size or color is seen to haunt a certain section of reef or shore, it is taken to be someone's ghost, and the name of a deceased person is allotted to it, while certain foods are set aside for such ghost sharks.

Incidentally, a curious parallel may be drawn between these islanders and a people from the other side of the world. Just as the Egyptian queens were sometimes buried in cow-shaped sarcophagi, in order to place them under the protection of Isis, so the Solomon Islanders, who worship sharks, deposit the dead bodies of chiefs or the skulls of common men in wooden images of these fish which stand in their temples or tambu houses (Frazer, 1910).

In the Hervey Islands, a deity named *Tiaio,* said to be a former king of Mangaia, took possession of a large white shark, the terror of these islanders, and he had a small sacred grove (marae) set aside for his worship.

Hawaiian shark lore is enormous. There were were-sharks, which took the form of man, but that could be recognized by a shark's mouth which appeared

on their human back, between the shoulder blades. There were shark gods, and an old Hawaiian oath was *"pau-pele, pau mano,"* which means "finished by the goddess of the volcano or by the shark," an invocation corresponding to the Christian's "before God" (Young & Mazet, 1934).

Hawaiian gods fell into several categories. Those born of the night held chief place among island deities, but among the lesser gods sharks held a unique position and were quite generally worshipped on all the islands, each one having a special shark or sharks as their *aumakuas* or ancestral god (Cobb, 1902).

On almost every headland temples stood dedicated to the worship of the shark, and if a man had a child stillborn, he endeavored, through a set ritual, to lodge its soul in the body of a shark, where it would become the guardian deity of his house.

Inevitably when man sets up a god, sacrifices, to appease the wrath or to obtain the favor of the deity, soon become a part of the ritual of worship. We have already noted such sacrifices among the *Tipenway* of Ponape and the setting aside of special food in the Solomons, as well as the construction of temples and the reservation of a sacred grove in Hawaii and the Hervey Islands (a custom followed to some extent in the Solomons), but primitive man went even further in his effort to propitiate his deities.

On Malaita a sacrifice of the first fruits was made to various animal deities. In the case of the ghost sharks this consisted of the first flying fish of the season. This was presented either on the altar of a shore-built temple, before the image of the shark, or, if a temple was lacking, the fish must be taken out to sea and shredded into the water as the names of the ghosts were called out. Then, and not before, might the fishermen partake of their catch.

A similar offering of the first fruits was made in Hawaii, where the first fish of each kind taken by the fisherman was always carried to the temple and offered to the shark god who was supposed to have driven them toward the shore. In these islands, however, the idea of sacrifice was carried to an extreme. When the king or priests imagined that the sharks wanted food, they sallied forth with their attendants, one of which carried a rope fashioned into a running noose. On coming to a group or crowd of people they threw the noose among them, and whoever happened to be taken in the snare—whether man, woman, or child—was immediately strangled and the body, cut into pieces, was flung into the sea to be bolted by the ravenous fish.

Betwen northern Australia and the island of New Guinea lies an extensive stretch of island-dotted water, known, after Luis Vaez de Torres, its discoverer, as Torres Straits. Here on the islands, as well as on the mainlands of Australia and New Guinea, live numerous tribes whose subsistence comes mainly from the sea. Hence it is little wonder that the elasmobranchs receive much attention from them and occupy a considerable place in their folklore, although these seems to be little evidence of any worship of them as deities.

Perhaps the closest approach to such worship lies in the use of these animals as totems throughout the territory (Haddon, 1903-35). For instance, among the eastern islanders inhabiting Uga, Erub, Mer, Dauar and Waier, we find tribal groups denominated as the *Wazwaz-le* (*Wazwaz*—sharkmen), while members of the group that may formerly have held totemic significance are the *beizam* (shark), *iruapap* (hammer-headed shark), the *kumazer,* a ray, and the *tapim* or stingray.

While totemism in the eastern islands is of little importance, being perperpetuated only by animal names, in the western islands it is a very real and potent influence. A list of the clans with a shark or ray totem is an imposing one. From Mabuiag we have the *Kaigas* (Guitar fish, *Rhinobatos* sp.), the *Baidam* (*Carcharias* sp.), *Kursi* (hammer-head shark) and the *Tapimal* (various kinds of ray) clans. In Badu the *Tapimul* was the chief clan while on Moa the clans were substantially the same as on Mabuiag. On Muralug the *Kutiku* (a kind of shark "with a hard skin") clan is added to the list, while on the mainland of New Guinea there is a clan known as the *Topinguros* or stingrays.

Sharks and sawfish both are believed to be connected with the fertility of the earth.

On Babud ceremonies were held to insure an abundant crop of yams, bananas, and coconuts. A collection of small stones was so arranged upon the ground of a garden that it formed the image of a shark or *beizam*. This image was admonished "You take care that we have plenty of food. You must not permit any man to steal from our gardens, nor rats to eat our food, nor birds to do damage. You must prevent all this."

The natives of Waiben, or Thursday island, performed a dance, known as the *waiitutu kap* or sawfish dance. This was accompanied by drum music and a chant known as the *waiitutu kap kudu,* or the Song of the Sawfish Dance. The dancers were elaborately masked, and the ritual designed to insure the fertility of their fields and the fullness of their fish-weirs.

On the island of Yaime, in the same group, two totemic animals, the crocodile and the hammer-headed shark, blossomed out into heroes named *Maiau* and *Sigai,* and their animal origin was kept a profound secret from women and uninitiated men, though in their sacred shrines the two worshipful beings were still represented by the images of a crocodile and a hammer-headed shark respectively. To these heroes prayers were put up and offerings of food were made, dances were danced and songs sung in thir honor. In short, totemism had here passed into a rudimentary religion (Haddon, *op. cit.*).

In the far east, only one other instance of religious veneration of sharks has come to my attention.

The Japanese, a sea-fishing people, have, as one of their legendary deities, a god of storm, called the shark man (Anesaki, 1928). However, there is evidence that they regard some members of the tribe with superstitious awe

and terrified fascination. This the famous "Flying Tigers" of Chennault took cognizance of when they painted the noses of their P-40 fighters with the grinning mask of a shark.

Aside from totemism and purely reliigous worship of the elasmobranchs, they were often regarded as avengers or ministers of justice.

Among the sea deities of the Tahitian islands were *Tuaraati* and *Ruahatu*, commonly known as *atu mao*, or shark gods, not that the gods themselves were incarnated as sharks, but rather because they used these fish as ministers of their divine vengeance. Another such agent of the gods was the white shark, which in Samoa, as a representative of *Moso*, served to guard the coconut trees and gardens of the natives. An image of the shark was plaited from coconut fiber, fins and other external characteristics being added. This image was then suspended in the coconut or breadfruit tree the owner desired to protect, or among the rows of his garden, and was tantamount to the expressed imprecation that the thief might be devoured by a white shark the next time he went fishing. So strong was this belief that the tale was told of a Christian who derisively thrust his arm into the maw of such a sham shark and who, on his next trip to the sea, lost both his arms to one of these marauders.

Sharks and rays were not always maleficent, however, for the south seas abound with tales of their helpfulness.

Ulap, the good spirit of the Mortlock islanders, had dominion over the fish and turtles of the sea, and on him, in time of trouble, the islanders were wont to call. On one occasion, so the islanders say, when a canoe capsized and the crew was surrounded by sharks, a prayer to *Ulap* brought forth an enormous shark with a spotted skin,* which drove the others away, thus saving the canoe men's lives (Frazer, *op. cit.*).

A Tahitian islander told Mr. Ellis (1831) that his father had been carried on the back of a shark from Raiatea to Huahine, a distance of twenty miles, and *Nei du Tuahine*, the stingray goddess already mentioned, was believed to take shipwrecked mariners upon her broad back, bearing them safely to shore.

The story of *Tawahaki* and *Rata*, which is current throughout the Pacific (Dixon, 1916) perpetuates, in legendary form, the general belief in the helpfulness of some sharks to men, and is reminiscent of the "swan-maiden" tales of the European continent. The Tahitian form of the legend represents *Tawahaki* as being able, by means of a powerful charm, to ride over the sea on the back of a shark, which carried him whither he listed.

In still another tale, *Hina* of Mangaia, beaten by her parents, called upon the fish of the sea to aid her in escaping a troubled existence. One after another they tried to carry her to the island home of *Tinarau*, the king of fishes.

* I have called the attention of Dr. E. W. Gudger to this passage, suggesting that this could be none other than a whale shark, the spotted skin being a characteristic of this selachian, and, in answer to my letter, he says "there is no reason to doubt that the spotted shark of the Mortlock islanders is *Rhineodon*."

All were too small for the task until at last a shark appeared which could carry the burden. *Hina* had with her two coconuts, to serve as food and drink upon the way, but when she broke one of them on the head of her fishy companion he became angry and dived. Fortunately, however, the greatest of all sharks perceived her distress and bore her safely to her journey's end.

As might be expected from the extent of shark worship in Hawaii, the legends of that country are rife with tales of sharks, and one, which might be said to be the Polynesian equivalent of the Ragnarok, has assumed epic proportions. A man-eater, *Mikolou,* having attacked natives of the island of Oahu, was lured by two shark gods of Ewa lagoon, *Kaahupahau* and her brother, *Kahi'uka,* to a feast, where he was stupefied by huge quantities of *awa,* the native drink. While in this condition the people of the surrounding territory captured him, dragging his body ashore and burning it. However, a portion of his tongue was inadvertently dropped into the sea. The spirit of the man-eater, revived again as a tongue, went forth to the coasts of Mauai and Hawaii, pleading with the sharks of those waters for vengeance against the sharks of Ewa lagoon. These, meanwhile, had secured the aid of the shark *Kuhaimoana,* dean of them all, and other notable sharks from the islands of Kaula, Niihau, Kauai and Oahu. The battle was joined and great deeds of valor were done on both sides. However, the cruel man-eater and his host were at last vanquished, leaving the goddess *Kaahapuhau* and her brother to enjoy the worship and friendship of a grateful people (Emerson, 1892).

The Peleu islanders have combined sharks with the solar myth (Frazer, *op. cit.*). These fish are traditionally the guardians of the House of the Sun, to which he retires at the end of the day. At the gates of the sunset stands a *denges* tree, whose fruit (so the story goes) is relished by the sharks. Each evening when the sun returns to the gates, he plucks some of the fruit and throws it into the water. Then, while the guardian sharks gobble their meal, he dives down to the bottom of the sea where he remains until a new day begins.

In another group of tales, sharks and sawfishes figure merely as actors and possess no divine or beneficent attributes.

Everyone remembers the story of Jonah and the whale (which was probably a shark), but few know that this myth is not peculiar to the Mediterranean region, or that it has its counterpart in the story of Mutuk, an islander of Torres strait (Haddon, *op cit.*). A comic tale from the same section tells of two old bachelors, *Markep* and *Sarkep,* who divided their duties, one searching for sawfish, the other searching for wives. All went well until they exchanged roles, when both met with disaster.

Even the Malays have a sprightly little tale wherein an ape, struggling in the sea as a result of past misdeeds, tricked a hungry shark into rescuing him from drowning and carrying him safely ashore.

The folklore of sharks is not, however, confined to primitive peoples (Radcliffe, 1926).

Stories and poems abound in the English language, all of which revolve about these fish, and with the relation of two of these, one of them a well authenticated fact, although it reads like the wildest fancy, and the other pure fiction of a Paul Bunyan vintage, I shall bring this paper to a close.

The first tale had its inception in the fertile brain of Mark Twain. A shark, while crusing in the Thames, swallowed a copy of the London Times, before the time of commercial cables and while communication still depended upon the mail boats. Seized with the wanderlust, our shark headed for Australia, reaching there some time before the steamer. Cecil Rhodes, then in Australia, caught the shark, opened it, and, seeing the paper, read the financial news. As a result of this advance information, he made a killing in the stock market, thus laying the foundation of his fortune, and making possible the addition of Rhodesia to the British Empire.

The second has its setting in the West Indies, off the island of Jamaica. Here, during the war of 1812, an American privateer, the Nancy, was operating to the detriment of his majesty's shipping until at last the British decided to end the nuisance. Chased by a man-of-war, the captain of the Nancy hurled his papers overboard in order that they might not show him in his true colors. Captured, and placed on trial in Jamaica, the court was about to discharge him and his crew scot-free when, unfortunately for them, a second British ship docked, bringing with it the missing papers which had been taken from the stomach of the shark that had evidently snapped them up when they were thrown overboard. The log of this second ship is on exhibition in London; the papers of the Nancy are in the museum of the Jamaica Institute, and the head of the shark in the British museum. Moreover, there is a sworn statement as to the truth of this tale at the Admiralty in London.

REFERENCES

ANESAKI, MASARKI 1928—Japanese, in "Mythology of All Races." Ed. by J. A. McCulloch, Marshall Jones and Co., Chicago.

BELL, CHARLES NAPIER 1899—Tangweera: life and adventures among gentle savages. London.

COBB, JOHN N. 1902—Commercial Fisheries of the Hawaiian Islands. Rept. U. S. Comm. Fish., 1901:381-500, pls. 21-26.

DANCE, CHARLES DANIEL 1881—Chapters from a Guianese log-book. Demerara.

DENNETT, R. E. 1907—Bavili Notes. Folk Lore, XVIII, 371-406, map & 3 pls.

DIXON, ROLAND B. 1916—Oceanic, in "Mythology of All Races." Ed. by J. A. McCulloch, Marshall Jones and Co., Chicago.

ELLIS, WILLIAM 1831—Polynesian Researches. 2nd. ed., 4 vols., illus., Fisherson and Jackson, London.

EMERSON, J. S. 1892—The Lesser Hawaiian Gods. Pap. Haw. Hist. Soc., No. 2.

FEWKES, J. WALTER 1922—A Prehistoric Island Culture Area of America. Ann. Rep. Bur. Amer. Ethnol., XXXIV, 35-281, 69 text figs., 120 pls.

FRAZER, SIR JAMES G. 1910—Totemism and Exogamy. 4 vols., McMillan and Co., London.

———1913-1924—The Belief in Immortality and the Worship of the Dead. 3 vols., Ibid., London.

———1935—The Golden Bough. 3rd ed., vol. 2, pp. 127, 292, 297.

GANN, THOMAS 1900—Mounds in Northern Honduras. 19th Ann. Rep. Bur. Amer. Ethnol., Pt. 2, pp. 655-692.

———1918—The Mayan Indians of southern Yucatan and northern British Honduras. Bull. U. S. Bur. Amer. Ethnol., LXIV.

HADDON, A. C., ET AL. 1904-1935—Reports of the Cambridge Anthropological Expedition to Torres Strait. 6 vols., Cambridge University Press.

MERWIN, RAYMOND E., & GEO. C. VAILLANT 1932—The Ruins of Holmul, Guatemala. Pap. Peabody Mus., III(2):i-xiv, 1-107, 36 pls.

OPPIAN—C. 176-180 Halieutica. Trans. by A. W. Mair. Loeb Classical Library, G. P. Putnam's Sons, New York, 1928.

PLINY—The Natural History of Pliny. Trans. by John Bostock and H. T. Riley. Henry G. Bohn, London, 1855.

RADCLIFFE, WILLIAM 1926—Fishing From the Earliest Times. 2nd. ed., John Murray, London.

ROTH, WALTER E. 1915—An Inquiry into the Animism and Folk-lore of the Guiana Indians. Bull. U.S. Bur. Amer. Ethnol., XXX, 107-453.

SMITH, A. LEDYARD 1932—Two recent ceramic finds at Uaxactun. Carn. Inst. Cont. Amer. Arch., No. 5 (2): pp. 1-25.

SWANTON, JOHN R. 1908—Social Conditions, Beliefs and Linguistic Relationship of the Tlingit Indians. Ann. Rept. Bur. Amer. Ethnol., XXVI, 391-486, pls. xlvii-lviii, figs. 103-117.

TOWNSEND, CHARLES HASKIN 1923—The Swordfish—Thresher Shark Delusion. Bull. N. Y. Zool. Soc., XXVI, 76-80.

TOZZER, ALFRED M. 1941—Landa's Relacion de las Cosas de Yucatan. Pap. Peabody Mus., XVIII, i-xiii, 1-394, 2 pls.

TURNER, GEORGE 1884—Samoa, A Hundred Years Ago and Long Before. McMillan and Co., London.

YOUNG, WILLIAM E., AND HORACE S. MAZET 1934—Shark! Shark!. Gotham House, New York.

A Further Contribution to the Classification of the North American Spider Parasites of the Family Acroceratidae (Diptera)

Curtis W. Sabrosky

Bureau of Entomology and Plant Quarantine, Agricultural Research Administration, U.S.D.A., Washington, D. C.

The small-headed flies of the family Acroceratidae (Acroceridae, Cyrtidae), whose known larvae are internal parasites of spiders, were monographed for North America in 1919 by F. R. Cole. In 1944, the writer published a revision of *Ogcodes* and *Acrocera* of the eastern United States. Subsequently a considerable amount of material from the Western States was made available for study, as well as additional eastern specimens, and it is now possible to present a more comprehensive analysis of the family, with special emphasis on *Ogcodes* and *Acrocera*. A few notes are presented on other genera, where these seem worthy of record. A generic key has not been included here, for several good published keys are available (e. g., Cole, 1919; Curran, 1934, "The Families and Genera of North American Diptera").

In this paper, approximately 870 previously unreported specimens are recorded, including over 370 in *Ogcodes*, 120 in *Acrocera*, 150 in *Opsebius*, 130 in *Eulonchus*, and 78 in *Pterodontia*.

The genera in this family are distinct and easily recognized, but in many cases it is difficult to find characteristics that will satisfactorily distinguish all individuals of what appear to be, or what have been considered to be, different species. Chief reliance has been placed in the past on color pattern, and convergent or overlapping variations have obscured specific distinctions and have undoubtedly resulted in many misidentifications. The analysis of many of these points of confusion has been hindered by the lack of adequate material, for these flies are relatively rare in collections besides which pinned specimens are all too often collapsed and shrunken, and difficult to determine with assurance.

Much remains to be learned about the classification and distribution of the Acroceratidae, as well as their habits and host relationships. In several instances, my present conclusions are admittedly tentative, and in one case (*Acrocera*, Group IV) it is deemed advisable to forego for the present any attempt at identification.

As in my 1944 revision, I have referred frequently to the excellent figures published by Cole (1919). Even though the present arrangement of species in some genera is rather different, Cole's paper is still essential for identifications in the family because of the large number of admirable illustrations. Taken together, the papers by Cole (1919) and Sabrosky (1944) figure most

of the American species, especially in the two largest genera, *Ogcodes* and *Acrocera*.

In a number of cases, the material cited by Sabrosky (1944) was reexamined in the course of the present study, but in the following pages the lists of "Material examined" include only new records, or published records that are here referred to other species. Likewise, detailed references for *Ogcodes* and *Acrocera* have been omitted where they merely duplicate the treatment in my previous review of those genera, unless some synonymy or corrections make it desirable to cite the references.

ACKNOWLEDGEMENT

The writer wishes to acknowledge with deep appreciation the loan of important collections from Dr. F. R. Cole, Mr. G. E. Bohart, Mr. H. J. Reinhard, Dr. C. H. Martin, the California Academy of Sciences through Dr. E. S. Ross, the Snow Collection of the University of Kansas through Dr. R. H. Beamer, the Museum of Comparative Zoology [MCZ, in the records] through Dr. J. Bequaert, the American Museum of Natural History [AMNH] through Drs. C. H. Curran and W. J. Gertsch, the Canadian Department of Agriculture through Mr. Guy Shewell, Cornell University Collection through Dr. Henry Dietrich, and Kansas State College through Dr. R. H. Painter. This material, together with the collection at the U. S. National Museum [USNM] and a few specimens from individual sources, is the basis of the present paper.

OCNAEA Erichson

Type, *Ocnaea micans* Erichson, by designation of Coquillett (1910, U. S. Natl. Mus. Proc. 37:577).

The key to species prepared by Aldrich (1932, U. S. Natl. Mus. Proc. 81 (art. 9):3) will still serve, with a few additions. Sabrosky (1946, *in* Stuardo, Catalogo de los Dipteros de Chile, pp. 190-195) described *O. stuardoi* and *O. meridionalis* from Chile, both of them easily distinguished from the other species by almost entirely shining black to bluish or purple body, black legs, and bright orange third antennal segment. Jenks (1938) validated the name *O. smithi* for a species from California, and another species from California is herein described as new.

It may be well to call attention again to the sexual dimorphism in the size and shape of the third antennal segment (cf. Sabrosky, 1946, l. c., p. 191). In the females the segment is much shorter than in the males, and sometimes clavate. Aldrich used the latter distinction in his key to separate *O. micans* Erichson and *O. loewi* Cole from the rest of the genus, but in view of the observed sexual dimorphism in the character, one is forced to suggest that the males of these species may be found under other names elsewhere in his key.

Of the 15 species included by Aldrich, plus four described since that time, at least seven were described from males only and three from females only, based on a total of 11 specimens. In only two cases (*O. stuardoi* and *O. smithi*) did an author have a series of specimens that included both sexes. It appears therefore that much still remains to be learned in this genus on the proper association of the two sexes, and the describer of new species should avoid being misled by the different form of the antenna.

It is of interest to note the correlation of two characters in *O. gigas* Aldrich and *O. falcifer* Aldrich. In both species (both based on males), the third antennal segment is unusually long, slender, and curving, extending below the lower margin of the head, whereas in the other males known to me the third segment is not extraordinarily long (cf. Cole, 1919, figs. 13a and 14a). In these two species, the aedeagus is strongly expanded distally, its breadth about twice that of a cercus, while in the species with the usual type of third antennal segment, the distal end of the aedeagus and each cercus are approximately equal in breadth.

Jenks (1938, Natl. Geog. Mag. 74:807-828) has reared *O. smithi* from the nests of the California trap-door spider, *Bothriocyrtum californicum* Cambridge, and has presented excellent photographs of all stages. It is quite possible that the habits of members of the genus are such that adults will rarely be collected on the wing and that attention to nests of trap-door spiders, and perhaps other spiders, would yield much material. It may be of interest here to note that one species of a related genus of the same subfamily, *Astomella hispaniae* Lamarck (= *A. lindenii* Erichs.), has been reared in Europe from a trap-door spider, *Cteniza areanea* K.

OCNAEA HELLUO Osten Sacken

Ocnaea helluo Osten Sacken, 1877, Western Diptera, p. 278. (Texas.)

The species was described from a single male, which I have examined in the Museum of Comparative Zoology. Beside it in the collection are two other specimens from Texas, one of which may have been collected at the same time as the type. They appear to be the same species, and it is only of interest here to point out two facts concerning them. One specimen, a male, has the first posterior cell closed in the right wing but open in the left, though the former is considered typical for the species .The other specimen, a female labeled "Tex." and "C. W. Johnson Colln.," has the third antennal segment only half as long as in the male. The abdominal pattern and other characters are identical with the type of *helluo*, and it is reasonably certain that it is the female of the species.

OCNAEA LOEWI Cole

Ocnaea loewi Cole, 1919, Amer. Ent. Soc. Trans. 45:26. (Texas.)

The species was described from one female, well illustrated by Cole (fig. 12, a, b). The antenna is shown to be relatively short and clavate.

A single female in the National Museum Collection, Dallas, Tex., October 29, 1938 (in cattle-fly trap), agrees with Cole's description and figure, except that in the right wing the posterior branch (R_5) of the fourth longitudinal vein reaches the margin of the wing, but leaves the first posterior cell narrowly open, while in the left wing it stops short of the margin as Cole has figured. Aldrich rightly recognized (1932, l. c., p. 2) that the venational picture in that area of the wing could not be relied upon.

OCNAEA SMITHI Jenks

Ocnaea smithi Jenks (ex Cole), 1938, Natl. Geog. Mag. 74:820-828, 12 figs. (California.)

The life history and all stages of this species, a parasite of the California trap-door spider, *Bothriocyrtum californicum* Cambridge, were beautifully figured by Jenks under the name of "*Ocnaea smithi*," a manuscript name furnished him by F. R. Cole. Unfortunately, Cole's description of *smithi* was not published before Jenks' article appeared, and has never since been published. There is some difference of opinion as to whether under Article 25, c, the name should be considered validly published by Jenks (1938). The prevailing opinion among taxonomists who have commented, and of the Committee on Nomenclature of the Bureau of Entomology and Plant Quarantine, is that the name was validated by Jenks, and I have accordingly so referred to it here. Through the kind cooperation of Dr. Cole, the original material sent by Jenks for determination has been examined, as well as the Riverside specimen captured by Harry S. Smith and referred to by Jenks as the basis for Cole's manuscript name. The material used by Jenks as the basis for his article has been regarded as the type series of *smithi* Jenks, and a lectotype has been selected.

The species is easily recognized from the excellent photographs published by Jenks, but a few notes may be added.

Male.—Head black, eyes densely covered with long brown hair; third antennal segment broad basally and strongly tapering toward the apex, in side view the breadth of the basal two-thirds twice that of the apical third and obviously broader than either first or second segment, the general appearance of the antenna as in figure 13c of Cole (1919) but proportionately much broader basally.

Mesonotum shining black, distinctly subvittate, a large subquadrate yellow spot in each anterolateral corner, extending posteriorly along the margin of the notum as far as the base of the wing, the resulting appearance being that of a complete, broad, median, black stripe with two anteriorly abbreviated lateral stripes which are fused with the median stripe on the posterior half of the notum; humeri entirely pale yellow, the upper portion of the mesopleura, the postalar calli, and the scutellum yellow in varying proportions, sometimes entirely black; thorax and abdomen densely covered with long, silken, pale yellow hair.

Dorsum of the abdomen as figured by Jenks, yellow with black markings as follows: The second, third, and fourth tergites basally with broadly triangular spots, the fifth and sixth tergites black as seen from above, but the sides yellow; venter of the abdomen typically entirely yellow.

Legs variably colored, sometimes predominantly yellow, but at least the femora more or less infuscated.

Female.—Like the male, but the third antennal segment shorter and somewhat clavate (similar to fig. 12b, of Cole, 1919); abdominal dorsum more

extensively yellow, the basal triangular spots smaller than in the male, subequal on tergites II-V.

Length, 9-12 mm.

Lectotype, male, Los Angeles, Calif., "from nests of *Bothriocyrtum californicum*" (G. E. Jenks). Type No. 58380 in the United States National Museum. Lectoallotype and four lectoparatypes (2♂, 2♀) [USNM and F. R. Cole Collection]. Undoubtedly, Mr. Jenks sent some of his original material to other institutions and individuals as well, and such specimens may also be considered lectoparatypes.

The female from Riverside, Calif., September 28, 1925 (Harry S. Smith), is not in good condition, but it seems to be somewhat different from the females reared by Jenks. The abdominal segments are bluish black and more extensively darkened, suggestive of the abdomen of male *sequoia* (cf. fig. 1), and it is quite possible that it is really the female of that species. In view of this doubt, as well as the fact that it was not part of Jenks' original material, I have not considered it in the type series of *smithi*.

In Aldrich's synopsis of the genus (op cit., p. 3), *smithi* will key out to *O. trivittata* Aldrich, from Honduras. The type of the latter, a male, is quite distinct in having a long, slender, falciform third antennal segment which tapers only slightly from base to apex, and whose greatest breadth is about equal to that of the first or second segments. The abdominal color pattern is also quite different, for *trivittata* has predominantly black-brown tergites, each with a narrow yellow hind marginal fascia of uniform width in dorsal aspect. *Ocnaea flavipes* Aldrich has a subvittate mesonotum like that of *smithi*, but abdominal tergites III-VI are chiefly orange with only a median row of narrow black spots.

Ocnaea sequoia, new species

Fig. 1

Dark species, with femora infuscated and abdomen dark metallic blue marked with yellow.

Male.—Agrees with the description of *O. coerulea* Cole (1919, p. 26, fig. 14, a-c) except in the following particulars: Third antennal segment distinctly longer than the height of the eye by 1.15 to 1.19 times (subequal in Cole's figure of *coerulea*); general shape of the antenna as figured for *coerulea* (Cole, fig. 14b), the breadth of the third antennal segment, in side view, subequal throughout the length, also subequal to the breadth of the second segment but slightly narrower than the first; entire thorax, except for the bright-yellow humeri and the reddish-black postalar calli, shining black, without bluish or purplish luster; scutellum entirely black; abdominal tergites dark metallic bluish black with yellow markings (fig. 1), the first, fifth and sixth entirely dark, the fourth dark as viewed from above, only obscurely yellowish at the edges, and the second and third broadly yellow on the sides like the pattern of *O. schwarzi* (cf. Cole, fig. 13), except that the black area reaches the posterior margin at least on the midline; venter of the abdomen dark brown

or brown black, sometimes with faint bluish luster laterally, each sternite with a narrow, straight, yellow fascia along its posterior margin; all coxae black except for narrow apex; all femora brown to black except narrowly at the base and at the knee, and a narrow dorsal stripe; hind tibiae more or less browned on the middle third; first posterior cell closed at the margin of the wing, or short petiolate; aedeagus not unusually enlarged distally, in breadth subequal to or only slightly broader than a cercus; length 9-10 mm.

Holotype, male, Potwisha, Sequoia National Park, Calif., June 13, 1929 (E. C. Van Dyke). Paratypes, male, same data as type, and male, same locality, July 1, 1941 (E. C. Van Dyke). Type and one paratype in the collection of the California Academy of Sciences, the other paratype in the United States National Museum.

In general appearance, the abdomen of this species appears to be entirely dark on the posterior half (tergites IV-VI) and marked with yellow on tergites II and III in a pattern reminiscent of *O. schwarzi*, the black basal areas more or less rounded posteriorly.

In Aldrich's key to the genus *Ocnaea*, *sequoia* will run to *coerulea* Cole, from which it is distinguished by the characters listed above. It is also similar to *O. helluo* O. S., but in the latter the coxae and femora are entirely yellow, the first abdominal tergite is yellow, tergites II through V are patterned like *O. schwarzi*, tergite VI is apically yellow, and the yellow fasciae along the posterior margins of the sternites are half as broad as a sternite.

This is the second species of the genus to be recorded from California, *O. smithi* being the first. Both species have the third wing vein strongly forked as in *Tabanus*, and the first posterior cell closed. The differences between the two are as follows:

Abdomen predominantly blue-black, the fifth tergite entirely so and the fourth all but a narrow margin (fig. 1); mesonotum black up to the humeri and postalar calli; third antennal segment of the male, in side view, approximately equibroad throughout its length, the breadth subequal to that of the second segment and obviously narrower than that of the first .... *sequoia* Sabrosky

Abdomen predominantly yellow, the tergites with crescent-shaped basal black spots, as figured for *O. loewi* (Cole, 1919, fig. 12); mesonotum subvittate in appearance, with a broad complete median stripe fused posteriorly with two abbreviated lateral stripes (Jenks, 1938, fig.); third antennal segment of the male broad basally and strongly tapering toward the apex, the breadth in side view over twice as broad on the basal two-thirds as on the apical third, and obviously broader than either first or second segment .... *smithi* Jenks

LASIA Wiedemann

Monobasic. Type, *Lasia splendens* Wiedemann.

LASIA PURPURATA Bequaert

Lasia purpurata Bequaert, 1933, Amer. Mus. Nat. Hist., Amer. Mus. Novitates No. 617:1-2 (Oklahoma); Steyskal, 1940, Brooklyn Ent. Soc. Bul. 35:158 (Oklahoma).

extensively yellow, the basal triangular spots smaller than in the male, subequal on tergites II-V.

Length, 9-12 mm.

Lectotype, male, Los Angeles, Calif., "from nests of *Bothriocyrtum californicum*" (G. E. Jenks). Type No. 58380 in the United States National Museum. Lectoallotype and four lectoparatypes (2♂, 2♀) [USNM and F. R. Cole Collection]. Undoubtedly, Mr. Jenks sent some of his original material to other institutions and individuals as well, and such specimens may also be considered lectoparatypes.

The female from Riverside, Calif., September 28, 1925 (Harry S. Smith), is not in good condition, but it seems to be somewhat different from the females reared by Jenks. The abdominal segments are bluish black and more extensively darkened, suggestive of the abdomen of male *sequoia* (cf. fig. 1), and it is quite possible that it is really the female of that species. In view of this doubt, as well as the fact that it was not part of Jenks' original material, I have not considered it in the type series of *smithi*.

In Aldrich's synopsis of the genus (op cit., p. 3), *smithi* will key out to *O. trivittata* Aldrich, from Honduras. The type of the latter, a male, is quite distinct in having a long, slender, falciform third antennal segment which tapers only slightly from base to apex, and whose greatest breadth is about equal to that of the first or second segments. The abdominal color pattern is also quite different, for *trivittata* has predominantly black-brown tergites, each with a narrow yellow hind marginal fascia of uniform width in dorsal aspect. *Ocnaea flavipes* Aldrich has a subvittate mesonotum like that of *smithi*, but abdominal tergites III-VI are chiefly orange with only a median row of narrow black spots.

Ocnaea sequoia, new species

Fig. 1

Dark species, with femora infuscated and abdomen dark metallic blue marked with yellow.

Male.—Agrees with the description of *O. coerulea* Cole (1919, p. 26, fig. 14, a-c) except in the following particulars: Third antennal segment distinctly longer than the height of the eye by 1.15 to 1.19 times (subequal in Cole's figure of *coerulea*); general shape of the antenna as figured for *coerulea* (Cole, fig. 14b), the breadth of the third antennal segment, in side view, subequal throughout the length, also subequal to the breadth of the second segment but slightly narrower than the first; entire thorax, except for the bright-yellow humeri and the reddish-black postalar calli, shining black, without bluish or purplish luster; scutellum entirely black; abdominal tergites dark metallic bluish black with yellow markings (fig. 1), the first, fifth and sixth entirely dark, the fourth dark as viewed from above, only obscurely yellowish at the edges, and the second and third broadly yellow on the sides like the pattern of *O. schwarzi* (cf. Cole, fig. 13), except that the black area reaches the posterior margin at least on the midline; venter of the abdomen dark brown

or brown black, sometimes with faint bluish luster laterally, each sternite with a narrow, straight, yellow fascia along its posterior margin; all coxae black except for narrow apex; all femora brown to black except narrowly at the base and at the knee, and a narrow dorsal stripe; hind tibiae more or less browned on the middle third; first posterior cell closed at the margin of the wing, or short petiolate; aedeagus not unusually enlarged distally, in breadth subequal to or only slightly broader than a cercus; length 9-10 mm.

Holotype, male, Potwisha, Sequoia National Park, Calif., June 13, 1929 (E. C. Van Dyke). Paratypes, male, same data as type, and male, same locality, July 1, 1941 (E. C. Van Dyke). Type and one paratype in the collection of the California Academy of Sciences, the other paratype in the United States National Museum.

In general appearance, the abdomen of this species appears to be entirely dark on the posterior half (tergites IV-VI) and marked with yellow on tergites II and III in a pattern reminiscent of *O. schwarzi*, the black basal areas more or less rounded posteriorly.

In Aldrich's key to the genus *Ocnaea*, *sequoia* will run to *coerulea* Cole, from which it is distinguished by the characters listed above. It is also similar to *O. helluo* O. S., but in the latter the coxae and femora are entirely yellow, the first abdominal tergite is yellow, tergites II through V are patterned like *O. schwarzi*, tergite VI is apically yellow, and the yellow fasciae along the posterior margins of the sternites are half as broad as a sternite.

This is the second species of the genus to be recorded from California, *O. smithi* being the first. Both species have the third wing vein strongly forked as in *Tabanus*, and the first posterior cell closed. The differences between the two are as follows:

Abdomen predominantly blue-black, the fifth tergite entirely so and the fourth all but a narrow margin (fig. 1); mesonotum black up to the humeri and postalar calli; third antennal segment of the male, in side view, approximately equibroad throughout its length, the breadth subequal to that of the second segment and obviously narrower than that of the first ....*sequoia* Sabrosky

Abdomen predominantly yellow, the tergites with crescent-shaped basal black spots, as figured for *O. loewi* (Cole, 1919, fig. 12); mesonotum subvittate in appearance, with a broad complete median stripe fused posteriorly with two abbreviated lateral stripes (Jenks, 1938, fig.); third antennal segment of the male broad basally and strongly tapering toward the apex, the breadth in side view over twice as broad on the basal two-thirds as on the apical third, and obviously broader than either first or second segment ....*smithi* Jenks

LASIA Wiedemann

Monobasic. Type, *Lasia splendens* Wiedemann.

LASIA PURPURATA Bequaert

Lasia purpurata Bequaert, 1933, Amer. Mus. Nat. Hist., Amer. Mus. Novitates No. 617:1-2 (Oklahoma); Steyskal, 1940, Brooklyn Ent. Soc. Bul. 35:158 (Oklahoma).

The holotype and the additional specimens noted by Steyskal all came from Oklahoma. No others appear to have been mentioned in the literature. The specimen recorded here represents a slight extension of the known range.

Material examined.—ARKANSAS: 1, Washington County, June 14, 1938 [Kans. State Col. Collection, det. R. H. Painter].

EULONCHUS Gerstaecker

Monobasic. Type, *Eulonchus smaragdinus* Gerstaecker.

It has seemed to me that some sexual dimorphism might be present in this genus, and the receipt of a fine series of over 120 specimens from Charles H. Martin made it possible to test that hypothesis.

I do not believe that the presence of short setae at the apex of the third antennal segment, as in *Pialeoidea,* has previously been noted for *Eulonchus.* In *E. smaragdinus,* from 1-5 (commonly 2) setae were present in the males and 1-2 (commonly 1) in the females. The setae are pale and delicate and no doubt easily broken off, which would probably account for the fact that their presence has not previously been noted.

KEY TO THE SPECIES OF EULONCHUS

1. Proboscis curved and usually extending considerably beyond the apex of the abdomen, rarely only slightly exceeding the apex; frontal triangle glabrous, and the oral margin with no long hairs but only a fringe of minute pale hairs; legs entirely yellow .... *smaragdinus* Gerstaecker
   Proboscis straight, never exceeding the apex of the abdomen and often much shorter; frontal triangle with a number of fine piliferous punctures, the triangle and oral margin with long pale hairs 2

2. Proboscis very short, extending only to the apex of the midcoxa; third antennal segment of the male large, as long as the head is high; legs entirely yellow North Carolina .... *marialiciae* Brimley
   Proboscis long, usually reaching nearly to the apex of the abdomen; third antennal segment of male not as large as in the previous species (far western) 3

3. Legs entirely yellow .... *sapphirinus* Osten Sacken
   Legs with at least the femora black 4

4. Legs with black femora, the tibiae yellow; squamae whitish .... *tristis* Loew
   Legs entirely black or brown, only the knees yellow; squamae margined with black .... *marginatus* Osten Sacken

EULONCHUS SMARAGDINUS Gerstaecker

Eulonchus smaragdinus Gerstaecker, 1856, Stett. Ent. Ztg. 17: 360. (California.)

This species is readily characterized by the very long proboscis, which at rest usually extends considerably beyond the apex of the abdomen (Cole, 1919, fig. 16). The length of the proboscis varies somewhat, from only slightly exceeding the apex (though only one specimen has been seen with this short a proboscis) to a total length equal to twice that of the body, the proboscis thus extending beyond the abdomen to a distance equal to the length of the body itself. The ocellar tubercle in profile is regular in outline, and the

median ocellus is not borne on a separate projection (Cole, fig. 16 compared with 17 and 18). A majority of the specimens before me are yellowish green, though some are a bright blue green; all have the dense, long, golden-yellow hairs that are characteristic of the species.

A very interesting difference was discovered which will separate *smaragdinus* from all the other species. The frontal triangle, the small area below the holoptic eyes and above the base of the proboscis, is smooth, highly polished and glabrous, and the linear oral margin has no long hairs but only a thick-set fringe of minute pale hairs. In the other species, the shine of the frontal triangle is interrupted by a number of fine piliferous punctures, each bearing a long, pale hair, with similar hairs along the entire oral margin and forming a close, even fringe. These hairs are slightly longer than the long hairs that cover the eyes, and are quite noticeable because of their regular even appearance flanking the mouth.

A strong sexual dimorphism exists in the form of the third antennal segment. Fortunately, this does not cause any synonymy in the specific name that is to be used, for even though not recognized as a sexual character, the dimorphic antennae were regarded merely as variants of the same species. The so-called blunt type of antenna figured by Cole (1919, fig. 16a) is that of the male sex; the sharp-pointed type, shorter and strongly acuminate (Cole, 1919, fig. 16b) is found in the females of the species.

These conclusions were evident particularly from a study of a series of 40-odd specimens collected on various dates in June and July in Monrovia Canyon, Calif., by Charles H. Martin. As noted in other cases in the family, males predominate in this material (35 males, 8 females). The longest series for a single date, July 4, 1930, showed 16 males and only two females.

I have seen examples of this species only from California (Monrovia Canyon, San Antonio Canyon, San Gabriel Mts., Mount Lowe, and Pacific Grove, and from San Francisco, Lake, Los Angeles, and San Bernardino Counties). Dr. Aldrich noted in his card catalogue that he had seen it from Utah.

Length of body: males, 8.5-11.5 mm.; females, 9.5-12 mm.

EULONCHUS SAPPHIRINUS Osten Sacken

Eulonchus sapphirinus Osten Sacken, 1877, Western Diptera, p. 276. (California.)

Like *smaragdinus* in having yellow legs, but with a shorter, straight proboscis, at most approximately equal to the length of the body, rarely barely exceeding the tip of the abdomen; ocellar tubercle in profile showing a separate distinct projection for the median ocellus (Cole, 1919, fig. 19). The species is much darker than *smaragdinus*, usually dark blue to purplish or dark green, with body hairs dark, at most a grayish yellow.

The same type of sexual dimorphism appears to be present in this species, though I have seen few females and these do not show as marked a difference as did the sexes of *smaragdinus*. Cole's figure 19b and 19d represent, respec-

tively, the male and female antennae, though most of the specimens I have seen have the former somewhat more slender.

The predominance of males over females in the available material (50 to 4) is quite striking. In the longest series seen, from Olympia, Wash., July 6, 1933 (C. H. and D. Martin), there were 20 males but no females.

Length, 7-10.5 mm.

Distribution.—Washington to California, and east to Utah. I have seen material from Cascade Mountains, Olympia, Sumner, Forks, Puyallup, Tieton, and Tumwater, Wash.; Parkdale, Siskiyou Mountains (Jackson County), and Breitenbush Springs, Oreg.; and Bellevue, Washington County, Utah. Various dates, May 28-July 23.

EULONCHUS TRISTIS Loew

Eulonchus tristis Loew, 1872, Centuria X, No. 19. (California.)

Eulonchus tristis is usually separated from the other species by the darker legs, with at least the femora black except at the knees. It has a large ocellar tubercle with separate median ocellar projection, and the oral opening is fringed as in *E. sapphirinus*. The same observation on sexual dimorphism in the form of the antenna applies here.

Several puzzling variations in structure have been seen in a few specimens, in such features as the size of the antennae and the point of their insertion between the eyes. It is possible that there are unrecognized species here, but the present material is not sufficient to study the problem.

A series from Breitenbush Springs, Marin County, Oreg., June 14, 1942 (R. E. Rieder), received from C. H. Martin, contains 14 males but only one female. Other specimens have been seen from Rainier National Forest, Mount Rainier, and Signal Peak, Wash.; Parkdale, Mount Ashland (Jackson County), and Blue Mountains, Baker County, Oreg., Kern River Canyon, Sequoia National Park, and Sonoma County, Calif.; and Mount Moscow, Idaho.

PTERODONTIA Gray

Monobasic. Type, *Pterodontia flavipes* Gray.

KEY TO THE AMERICAN SPECIES OF PTERODONTIA

1. Terminal antennal segment slender, at least five times as long as its greatest diameter; ultimate sections of both third and fourth veins present (cf. Cole, 1919, fig. 20, 20a) 2

   Terminal antennal segment short and broad, its length and breadth subequal, or barely longer than broad; apparently only the third vein present, at least only a single unforked vein in the apical portion of the wing (cf. Cole, 1919, figs. 21, 21a, 22, 22a) 3

2. Discal cell closed and angulate distally, a short cross vein between the ultimate sections of the third and fourth veins; costa in the males with a relatively weak toothlike projection (Cole, 1919, fig. 20) (western) .... *vix* Townsend

   Discal cell not completely closed distally, not angulate, the ultimate sections of third and fourth veins appearing as widely divergent forks of the third vein;

costa in the males with a strong toothlike projection (eastern) ....
....*westwoodi*, new name (= *analis* Westw. nec Macq.)

3. Abdomen entirely black or pitch black (Washington to California) ..*johnsoni* Cole
Dorsum of abdomen bright orange or orange yellow, with black markings 4

4. Mesonotum not entirely black, a large subquadrate spot in each anterior corner, and a prescutellar triangular spot, orange ....*notomaculata*, new species
Mesonotum black up to the humeri and postalar calli ....*flavipes* Gray (cf. discussion under *flavipes* for the status of *misella* O. S. as a synonym or weakly defined subspecies).

PTERODONTIA VIX Townsend

Pterodontia vix Townsend, 1895, Calif. Acad. Sci. Proc. 4:607. (Lower California.)

The closely related *Pterodontia vix* Tns. and *P. westwoodi* Sabr. (= *analis* Westw., preoccupied) are the only species of *Pterodontia* which I have seen that are distinguished by clearly marked structural characters. The others are dependent on color pattern, with variations that sometimes make a proper understanding of specific limits rather difficult in a group where specimens are seldom collected and long series are extremely rare.

Cole (1919, fig. 20, 20a) figured the male of *P. vix* (as *P. analis*), and the figures illustrate clearly the characteristic wing venation and the slender elongate terminal segment of the antenna. On the abdomen, the first three tergites are black (the anterolateral angles of the third are usually inconspicuously yellow), a broad black median spot occupies a third or more of the dorsum of the fourth tergite, and the rest of the dorsum is bright orange. Some specimens have a small spot on each side of the fourth tergite (Cole, fig. 20) and a small median spot at the base of the sixth; in others these are insignificant or even absent. The venter of the abdomen, except for the first sternite, is yellow. The fore femur is slightly infuscated, especially on the posterior surface, the mid and hind femora are entirely black, and the tibiae and tarsi bright yellow.

Two females have also been seen which agree with the males in both wing venational and antennal characteristics, and even though they differ in color pattern, I have associated the two sexes because of these structural features. The females are not in good condition, but the dorsum of the abdomen appears to be entirely black, and the fore femur is darker than in the males. As usual in the female sex, the costal margin lacks the toothlike projection found in the males.

Length, 5-5.5 mm.

Townsend described the species from two specimens from Baja California. The cotype deposited in the California Academy of Sciences was destroyed in the great fire of 1906. A sketch of the wing venation was made by Dr. J. M. Aldrich in October 1905. The other cotype is in the early Townsend material now in the Snow Collection at the University of Kansas, and I hereby designate it as the lectotype.

Material examined.—CALIFORNIA: Three males, Santa Cruz Mountains [USNM]; male, Sand Dunes, San Francisco, May 28, 1940 (E. S. Ross); two females, Riverton, El Dorado County, July 18, 1931 (E. C. Van Dyke) [Calif. Acad. Sci.].

Pterodontia westwoodi Sabrosky, new name

Pterodontia analis Westwood, 1848, Ent. Soc. London, Trans. 5 (pt. 4): 97 (Georgia) (preoccupied by *P. analis* Macquart, 1846, Dipt. exot., suppl: I: 98-99, pl. 9, fig. 3 [pp. 226-227 in Mémoires], New Granada = Colombia); Melander, 1902, Ent. News 13: 179 (Woods Hole, Mass., record repeated by Johnson, 1925, Dipt. New England, p. 106); Cole, 1919, Amer. Ent. Soc. Trans. 45: 40 (description repeated, figs. 20 and 20a are of *P. vix* Tns. (q. v.) listed by Cole as a synonym of *analis*); Cole, Malloch, and McAtee, 1924, Ent. Soc. Wash. Proc. 26: 181 (Beltsville, Md.); Brunetti, 1926, Ann. and Mag. Nat. Hist. (ser. 9) 18: 577-578 (notes on ♂ type in British Museum (Nat. Hist.)).

This is apparently a rarely collected species. I have seen only a single male, from Sea Cliff, Long Island, N. Y. (N. Banks) [MCZ]. Westwood's description of the type specimen fortunately contained the essential characters, including a statement that the discal cell was "sub apicem alarum postice aperta." It was suggested in a previous paper (Sabrosky, 1943, pp. 181-182) that *vix* and *analis* would probably be found to be distinct, but only recently were specimens available to test this hypothesis.

The remarks under *P. vix* on the color and color pattern of the males apply equally well here.

Macquart stated that his species from Colombia had four posterior cells in the wing, instead of three as in *P. flavipes*, and his figure shows clearly that the discal cell is closed and angulate distally. This is the venation of *P. vix* Tns., as shown in Cole's excellent figure (1919, fig. 20), but no South American material is available to determine the relationship of *vix* and *analis* Macquart. Specimens of *P. analis* Westwood from eastern United States, however, have a different venation (cf. key), and this species is therefore maintained as distinct, under a new name to replace the homonym.

Westwood's figure (1876, Ent. Soc. London, Trans., pl. 6, fig. 1, 1a) of his *Pterodontia dimidiata*, also described from Colombia, shows that it falls in this same group of species having an extra vein arising from the discal cell. From the figure it appears to be slightly different from *analis* Macquart in wing venation, but has the same color pattern on the abdomen. Whether they are distinct species or not will have to be determined from a study of the types and adequate South American material.

Incidentally, Brunetti (1926, op. cit., p. 577) was palpably in error in citing *P. analis* Macquart from Colombia as a synonym of *P. macquartii* Westwood. The latter was proposed as a new name for *P. flavipes* Macquart (nec Gray) from Australia (probably = *P. mellii* Erichs.). Besides the doubt cast by association of two such widely separated species, Macquart's figure of his *flavipes* (Dipt. exot., II, pt. 1, pl. 1, fig. 2) clearly shows that it has the same reduced type of venation as *flavipes* Gray, and this is borne out by Macquart's comparison of the wing venation of his *flavipes* and *analis* (Dipt. exot., suppl. I:99).

PTERODONTIA JOHNSONI Cole

Pterodontia johnsoni Cole, 1919, Amer. Ent. Soc. Trans. 45:42. (Washington, Idaho.)

In an earlier paper (Sabrosky, 1943), I was misled by the apparent association of sexes in a small series of specimens into suggesting that *P. misella* was dimorphic and that *P. johnsoni* was the dark-bodied female. However, in material received from the California Academy of Sciences were two males with entirely black bodies.

The species appears to me now to be valid, based on the entirely black thorax and abdomen. The only bright color on this species appears on the legs, which have the pattern that might almost be said to be a generic character—males with black mid and hind femora but the remainder of the legs yellow, females the same but the fore femur also more or less infuscated. No structural difference could be found to distinguish the species from the *flavipes-misella* complex.

Length, 5-7.5 mm.

Material examined.—CALIFORNIA: Two males, Santa Cruz, July 18, 1924 (F. E. Blaisdell), and Trinity County, May 30, 1917 (E. R. Leach) [Calif. Acad. Sci.]; female, Lone Pine, July 28, 1940 (D. E. Hardy) [Kans. Univ.]; male, Pismo, August 1, 1930 (T. F. Winburn) [R. H. Painter Collection]. IDAHO: Two females (paratypes), Boise (D. C. Petrie) [USNM]. OREGON: Female, Hood River, June 10, 1920 (Childs) [F. R. Cole Collection]. Further, the two females from Lake Cushman, Mason County, Wash., and Vancouver, British Columbia, recorded as *P. misella* by Sabrosky (1943, p. 181), should be referred here.

Pterodontia notomaculata, new species

Differs from all other known American species of *Pterodontia* in having a color pattern on the mesonotum.

Male.—Similar to *P. flavipes* Gray in general structure, with the same type of antenna and wing venation (cf. key); thorax more brightly colored, with a large, subquadrate, bright-orange spot in each anterior corner of the mesonotum, mesad and postero-mesad the black humerus, and the postalar callus, scutellum, a prescutellar triangular spot on the mesonotum sometimes, and about three-fourths of the large mesopleuron usually, orange; otherwise, the central area of the mesonotum is shining black, propleuron the same, and the lower and posterior parts of the pleuron brown; dorsum of the abdomen similar to *flavipes* but more extensively bright orange, only the narrow first tergite entirely, three subquadrate spots on the second, and a narrow median spot on the third, black; venter entirely brown; halter with black knob and yellow stalk; legs as in *flavipes*, typically yellow with black mid and hind femora; costal tooth weak.

Length, 4.5-7 mm.

Holotype, male, Lone Pine, Calif., July 28, 1940 (L. J. Lipovsky). Type in the Snow Collection, University of Kansas. Paratypes: Seven males same data as holotype [Kans. Univ. and USNM]; male, Vina, Calif., June 7, 1920 (C. T. Dodds) [Calif. Acad. Sci.]; male, Parma, Idaho, July 4, 1934 (C. H. Martin) [Martin Collection].

As in all acrocerids, there is variation in the extent of the color. All individuals show the posthumeral spots and the orange spot on the mesopleuron.

In most examples, these are large and conspicuous, but in the darkest example, they are quite reduced. Four specimens lack a prescutellar spot, and the other five show it in varying degree. In all specimens, even the one with the most extensive black areas, the black on the second abdominal tergite is divided into three separate areas, a median and two lateral. Only one specimen shows a median black spot on the fourth tergite.

All other American species of *Pterodontia*, and most of those of the world, have the mesonotum shining black. Only *P. kashmirensis* Lichtwardt, from Kashmir, has a color pattern similar to *notomaculata*, but in that species the abdomen is extensively marked with black.

PTERODONTIA FLAVIPES Gray

Pterodontia flavipes Gray, 1832, *in* Griffith, Animal Kingdom, v. 15, p. 779, pl. 128, fig. 3.

Pterodontia misella Osten Sacken, 1877, Western Diptera, p. 277. (Oregon.) Weakly defined western subspecies (?).

I had previously regarded *flavipes* and *misella* as distinct eastern and western species, based partly on color characters, but mainly on what seemed to be a striking sexual dimorphism in the western *misella* (Sabrosky, 1943, pp. 180-181). Realization of the latter error (cf. discussion under *P. johnsoni*) has eliminated that consideration, and further, a recent opportunity to study a number of far western specimens demonstrated that the apparent differences in color and size are not reliable. Certain characteristics seem indeed to be rather distinctive in most specimens; for example, western individuals almost always have a median black vitta on the dorsum of the fourth abdominal segment, whereas in eastern specimens this tergum is usually entirely orange, or at most with only a narrow vitta. Likewise, in western males, the costa seemed to be more abruptly bent forward just proximad to the toothlike projection than in eastern specimens. But there were exceptions for all characters. The male genitalia of eastern and western examples were also compared, but no differences could be found. When one is forced to fall back on locality labels, it seems necessary to abandon *misella* as a distinct species and to regard it as at best a weakly defined western subspecies with a darker habitus than the larger and somewhat more brightly colored eastern race.

The records now available indicate that the species is widely distributed, and, for this uncommon family, relatively abundant. In the following list, the eastern and western records have been separated. There are few records from the plains and mountain states, but this may not be significant in view of the comparative rarity of these flies even in collections from states that have long been intensively explored for insects.

Material examined.—Eastern (typical *flavipes*): Nineteen specimens (10♂, 9♀), from 15 localities in Arizona, Illinois, Kansas, Maryland, Massachusetts, Michigan, New Hampshire, New Jersey, New York, North Dakota, West Virginia, Ontario, and Quebec. July 1-August. Interesting record; Male, South Tea Lake, Algonquin Park, Ontario, July 3-10, 1945 (W. Ivie and T. B. Kurata, "found in web of *Coras montanus* Emerton") [Royal Ontario Mus.]. One male, Oak Creek Canyon, Ariz., July (F. H. Snow) [Kans. Univ.], resembles the eastern form and is referred here.

Western (subspecies *misella* (?)): Thirty-three specimens (30♂, 3♀), from 17 localities in California, Idaho, Oregon, Utah, Washington. May 5-July 20.

OPSEBIUS Costa

Monobasic. Type, *Opsebius perspicillatus* Costa, which is a synonym of *O. inflatus* (Loew).

KEY TO THE NORTH AMERICAN SPECIES OF OPSEBIUS

1. Anal vein extending to the margin of the wing, the anal cell broadly open 2
   Anal vein not extending to the margin, either curving forward to join the sixth vein and close the anal cell, or ending well before the margin, at or near the point where it would normally curve forward toward the sixth vein 4
2. Costa not toothed (Eastern United States; only females known) .... *sulphuripes* Loew
   Costa strongly toothed, as in male *Pterodontia* (only males are known for the two species here) 3
3. Wing hyaline, at most yellowish (eastern United States; male of *sulphuripes* (?)) ....*pterodontinus* Osten Sacken
   Anterior third to half of the wing heavily browned (Haiti) ....*brunnipennis*, new species
4. Far western species (Washington, California)[1] ....*diligens* Osten Sacken
   Eastern species (Pennsylvania)[1] ....*gagatinus* Loew

OPSEBIUS DILIGENS Osten Sacken

Opsebius diligens Osten Sacken, 1877, Western Diptera, p. 278 (Vancouver Island, British Columbia); Cole, 1919, Amer. Ent. Soc. Trans. 45:46-47; James, 1938, Kans. Ent. Soc. Jour. 11:22 (Boulder, Colo.).

Opsebius paucus Osten Sacken, 1877, op. cit., p. 279 (California); Cole, 1919, op. cit., p. 47. New synonymy.

Opsebius diligens var. *hyalinus* Cole, 1919, op. cit., p. 47 (California). New synonymy.

The distinctions between *diligens*, *paucus*, and *hyalinus* were never clear to me in the few specimens that I had previously examined. However, the receipt of a fine series of about 40 specimens from the collection of the California Academy of Sciences, 55 from the collection of G. E. Bohart, 21 in the United States National Museum, and smaller lots from several sources, made its possible to test the characteristics that have been used for their separation.

It seems certain that the character of the open or closed anal cell is misleading in these far western *Opsebius*. In a series of 10 specimens collected on the same date at Nogales, Ariz., all are remarkably uniform in size, color and vestiture, and all are the same sex (male). In three the anal cell is closed (cf. Cole, 1919, fig. 23), in five the cell is open (as shown by Cole, 1919, fig. 25), in one the cell is closed in the right wing but open in the left, and in

---

1 I have seen no material of *gagatinus* Loew and am unable to give a satisfactory means of separating these two species. At present it seems best merely to indicate their distribution, in the hope that adequate eastern material may some day be found.

one specimen the cell is closed in the right wing, and almost so in the left but the veins do not quite join. In a longer series of 60 specimens, 30 males and 19 females have the anal cell closed, eight males have it open, and three males have the cell open in one wing and closed in the other. Apparently the closed cell is the typical form, and in occasional specimens the apical portion of the vein fails to develop and join the sixth vein. The character of the relative length of the third and fourth posterior cells, also used in Cole's key to the genus (1919, p. 44), is extremely variable, and again the two wings on the same specimens do not always agree. The unreliability of these characters leads inevitably to the conclusion that *diligens* and *paucus* are based on variations in wing venation, for no other means of separation can be found. However, whether the anal cell is open or closed, the anal vein definitely does not reach the margin of the wing, and thus the western species is distinctly different from the eastern *O. sulphuripes* (Cole, 1919, fig. 24).

Another feature which has attracted attention is the browned wings of some individuals, compared with the hyaline wings of others (= var. *hyalinus* Cole). The series of 120 specimens is adequate to show that this is a sexual character, the males almost always having clear wings and the females brown, with some variation in the extent and intensity of color.

In a few specimens, the erect hairs on the thorax and abdomen seem longer, denser, and deep yellow, whereas most of the specimens have whitish to yellowish-white hairs of only moderate length, and often show an oval patch of yellow hairs on each side of the mesonotum above the wing base. Even here, there are intermediates, and no consistent characters can be found to separate the material.

It is concluded, therefore, that no characters consistently separate the specimens into definable segregates, and all are here recorded as one species, *Opsebius diligens* Osten Sacken.

Material examined (128 specimens).—ARIZONA: Ten males, Nogales, April 3, 1921 (E. P. Van Duzee) [Calif. Acad. Sci.]; two males, Williams, June 3 and 6 (H. S. Barber), and one female, July 24 (Barber & Schwarz) [USNM]. WASHINGTON: Female, Rochester, July 22, 1931 (J. Nottingham) [Kans. Univ.]. CALIFORNIA: Eighty-six males, 28 females, from 26 scattered localities; various dates, April 20-July 23, August 2, and August 15-31.

OPSEBIUS SULPHURIPES Loew

Opsebius sulphuripes Loew, 1869, Centuria IX, No. 68. (New York.)

Relatively few specimens have been seen of typical *sulphuripes*, and all have been females. It is very possible that the male sex is known under the name of *O. pterodontinus* (q. v.).

Material examined (all USNM).—MARYLAND: Glen Echo (R. M. Fouts). MINNESOTA: Olmsted County (C. N. Ainslie). MISSOURI: St. Louis (Phil Rau).

OPSEBIUS PTERODONTINUS Osten Sacken

Opsebius pterodontinus Osten Sacken, 1883, Berlin. Ent. Ztschr. 27:299 (Texas.)

A number of additional specimens of the form with conspicuously toothed costa (Cole, 1919, fig. 26) have now been seen, and they are all males, as noted by Sabrosky (1943, pp. 177-178) for previously recorded specimens. All examples of *O. sulphuripes*, however, are females, and it seems quite likely that the two are really male and female of the same species. The fact that the form known as *pterodontinus* is more common is easily accounted for by the usually greater frequency of male acrocerids in collections (e. g., see the discussions under *Eulonchus* spp.).

Another species, *O. gagatinus* Loew, was also based on the female sex, but the type has the anal cell closed, whereas both *sulphuripes* and *pterodontinus* have the cell open and the anal vein extending to the margin of the wing. *O. gagatinus* appears to be an extremely rare species of which few specimens have been found.

Material examined.—Seventeen specimens from 15 localities in Connecticut, Georgia, Illinois, Michigan, Mississippi, Missouri, New Hampshire, New Jersey, Virginia, Ontario, Quebec. June 9-September 4, with one record from Stone Mountain, Ga., November 18, 1945 (P. W. Fattig) [Emory Univ. Collection].

Opsebius brunnipennis, new species

Near *O. pterodontinus* O. S., but the anterior half of the wings heavily browned.

Male.—Body hairs dark reddish yellow, squamae dark, and the costal tooth not as strikingly produced, only half as long, as in *pterodontinus;* wings not entirely hyaline as in that species, but the anterior third to half, including the entire first basal, marginal and submarginal cells, heavily browned, with adjacent cells faintly so; otherwise as described for *pterodontinus*.

Holotype, male, Furcy, Haiti, July-September, 1942 (A. Curtis). Type No. 58364 in the United States National Museum.

I believe that this is the first record of the genus from outside of the United States, in the Western Hemisphere.

ACROCERA Meigen

Monobasic. Type, *Syrphus globulus* Panzer.

Since the 1944 paper was prepared, a considerable amount of material has been examined, necessitating a revision of the status of certain species and extension of the known range of others. The key has been revised to include all of the described North American species.

It may be noted in passing that in the latest revision of the palaearctic species (1936, *in* Linder, Palaearktischen Fliegen, family 21), Sack recognized the genus *Paracrocera* Mik for species with the second vein (R_{2+3}) lacking (= Groups II-IV of Sabrosky, 1944). In view of the existence of intermediate species such as *A. bimaculata* Loew, which has only an apical rudiment of the vein, at least in one sex, and *A. nigrofemorata* Meigen of Europe which has only the basal part present, the distinction can hardly be maintained as a generic criterion. The species of the genus *Acrocera* are all remarkably similar in structure, and even reliable specific distinctions are sometimes difficult to find.

KEY TO THE NORTH AMERICAN SPECIES OF ACROCERA

1. Second longitudinal vein (R_{2+3}) present and complete 2
 Second vein represented by a short but distinct apical rudiment (Cole, 1919, fig. 32) .... *bimaculata* Loew
 Second vein entirely absent 7

Group I.—Venation complete, second vein present

2. Mesonotum with three black stripes, or if confluent posteriorly, the anterior half of the mesonotum is chiefly yellow to orange with a disinct median stripe 3
 Mesonotum black except for the humeri and postalar calli 5
3. Median stripe broad, terminating abruptly far before the scutellum (fig. 5); scutellum pale yellow .... *stansburyi* Johnson
 Median stripe usually much narrower, either complete or tapering and weakly abbreviated on the posterior slope of the mesonotum 4
4. Lateral spots on abdominal tergites II-IV actually sublateral, not at the extreme margins of the tergites, though appearing so in dorsal aspect; usually with bright habitus, the mesonotal stripes narrower and abdominal spots smaller than in the following species (Cole, 1919, fig. 30) (far western states) .... *liturata* Williston
 Lateral abdominal spots at the extreme margins of the tergites, usually more extensive than in the preceding species; habitus usually darker, the mesonotal stripes broader and abdominal spots larger than in the preceding species (Eastern States) .... *subfasciata* Westwood
5. Coxae entirely black; cerci in the female narrowly acuminate on the distal third .... *arizonensis* Cole
 Coxae yellow; cerci more or less acute but not narrowly acuminate 6
6. Dorsum of the abdomen predominantly black, the color pattern as in figure 1 and 1a of Sabrosky (1944), the median black triangles large and usually completely separating the two yellow spots on each tergite .... *steyskali* Sabrosky
 Dorsum of the abdomen predominantly yellow, the female as figured by Cole (1919, fig. 34), the male of the type figured by Sabrosky (1944, fig. 3a), the median black triangles broad basally but short, extending at most half the length of the segment .... *bakeri* Coquillett
7. Third longitudinal vein (R_{4+5}) forked, both branches present and distinct (Group III) 8
 Third vein with the anterior branch absent, except perhaps for a basal stub, sometimes its position indicated by a fold .... Group IV
 (For an outline of the different forms that have been found in this group, see the discussion under the heading of Group IV.)

Group III.—Both branches of third vein present

8. Sternites of abdominal segments II-V broadly black, with much narrower yellow fasciae along their posterior margins, the black area equally broad mesally and laterally (Sabrosky, 1944, fig. 2a); female cerci long acute (cf. Cole, 1919, fig. 32a) .... *fasciata* Wiedemann
 Sternites of abdominal segments II-V chiefly whitish yellow, the basal black fasciae quite narrow mesad but almost as broad as the segment laterad, thus giving the yellow area on each sternum an anteriorly convex margin (Sabrosky, 1944, fig. 4a); female cerci short acute (cf. Cole, 1919, fig. 27b) 9
9. Second abdominal tergite with a large black median triangle separated from the anterolateral black areas, usually with similar triangles on tergites III and IV .... *convexa* Cole

Second abdominal tergite with a broad black fascia along the entire anterior third 10

10. Males 11

Females. It is difficult to separate the females of the three species that come here. The distinctions given by Sabrosky (1944, p. 400, couplets 13 and 14) are not entirely reliable. In general, it may be said that *hubbardi* has a darker habitus than the others, with less extensive yellow areas on the abdomen (Sabrosky, fig. 3). The variation is confusing, however, and females cannot be determined with certainty.

11. Both second and third abdominal tergites typically with complete basal black bands, and a nearly complete black band on the fourth (Sabrosky, 1944, fig. 3a) .... *hubbardi* Cole (= *hungerfordi* Sabr.)

Only the second tergite with a complete black fascia, the third and occasionally the fourth with only small median black triangles 12

12. Third and fourth tergites with a considerable extent of black anterolaterally, in profile the black extending dorsad along the anterior margin from one-third to one-half the height of the tergite (Cole, 1919, fig. 36a); propleuron usually partially yellow; fifth abdominal segment as usual, telescoped beneath and partly hidden by the fourth segment .... *unguiculata* Westwood

Third and fourth tergites with only a small area of black in the anterolateral corners (Cole, 1919, fig. 36b); propleuron black; fifth segment not telescoped but characteristically indented, its entire dorsum visible in caudal aspect (Cole, 1919, fig. 36b, appearance in profile) .... *obsoleta* Van der Wulp (?)

ACROCERA LITURATA Williston

Acrocera liturata Williston, 1886, Amer. Ent. Soc. Trans. 13:294. (Washington.)

The relation of the western *liturata* and the eastern *subfasciata*, if they are distinct, is not at all clear from the few specimens in collections. In general, the eastern form has a darker habitus with three broad black mesonotal stripes and large black median triangles on abdominal tergites II-IV (Cole, 1919, figs. 38, 38a), or the stripes are even confluent posteriorly and the abdominal triangles are connected basally to form tridentate fasciae on tergites II and III (Sabrosky, 1944, fig. 8). The western form, long recognized under the name *liturata*, has a much brighter habitus, appearing predominantly orange yellow because of typically narrow mesonotal stripes (Cole, fig. 30).

Because of apparently overlapping variation, however, it is diffi;cult to indicate a clear-cut distinction between the two. For the present, I continue to regard them as distinct, but with a caution that adequate material may ultimately prove them to be at most only subspecies. *Acrocera stansburyi* Johnson, which also has three black mesonotal stripes, is quite distinct and is not involved in the *liturata-subfasciata* problem.

Material examined.—CALIFORNIA: Female, Mount Eddy, 8,000 ft., July 28, 1918 (E. P. Van Duzee) [Calif. Acad. Sci.]; female, Fallen Leaf, July 25, 1932 [G. E. Bohart Collection]. OREGON: Female, Byers, July 23, 1934 [AMNH]. WASHINGTON: Male, Puyallup, May 22, 1934 (W. W. Baker) [C. H. Martin Collection]; male, Signal Peak, July 4, 1930 (A. R. Rolfs); female, Friday Harbor, July 23, 1905 (J. M. Aldrich), cited by Cole (1919, p. 57) [USNM].

The female from Cedar Pass, S. Dak., described by Cole (1919, p. 56),

has been reexamined and is referred here to the eastern *subfasciata* rather than to *liturata*.

ACROCERA SUBFASCIATA Westwood

The problem of this species and *liturata* Williston has been discussed under the latter name.

The abdomen of the Michigan specimen recorded below is much darker than any other that has been seen. The basal black bands are more regular and the median triangles not as outstanding as figured in my earlier paper (1944, fig. 8). The abdominal pattern rather resembles that shown in figure 5 (1944), and the specimen might easily be confused with another species but for the characteristically striped thorax (Cole, 1919, fig. 38a) and the complete wing venation.

Material examined.—MASSACHUSETTS: Female, Northboro, August 28, 1944 (C. A. Frost, "tree trunk") [MCZ]. MICHIGAN: Female, Oakland County, June 30, 1935 (G. Steyskal) [Steyskal Collection]. OHIO: Female, Columbus, August 14; female, West Jefferson, Franklin County (J. Bequaert) [MCZ]. SOUTH DAKOTA: Female, Cedar Pass (W. H. Over), recorded as *liturata* by Cole (1919, p. 56) [USNM]. WISCONSIN: Male, Rochester, July 14, 1890 (F. Rauteb) [AMNH].

ACROCERA STANSBURYI Johnson

Acrocera stansburyi Johnson, 1923, Psyche 30:49. (Utah.)

A number of specimens, including the type series, have been seen from several different collections, all bearing the same data, Stansbury Island, Utah, June 13, 1913 (Hagan-Titus), and oddly enough all males. The broad median stripe, abruptly terminated far before the scutellum, and a slightly different type of abdominal pattern, distinguish the species from the *liturata-subfasciata* complex. All specimens that I have seen are of small size, only 3 mm. at most, whereas the others ranged from 4.5-5.5 mm. in length. Size is of course an unreliable criterion in these parasitic flies, but the consistently small size of the Utah series may be a significant indication.

The species has never been figured, and a drawing of the thorax and abdomen will greatly assist in recognizing it (fig. 5).

No records are known to me except for the type locality.

ACROCERA ARIZONENSIS Cole

Acrocera bakeri var. *arizonensis* Cole, 1919, Amer. Ent. Soc. Trans. 45: 51, fig. 28 (Arizona.)

The female holotype [USNM] is unquestionably close to *bakeri* Coq., and a long series might show that it is merely a variant. It differs in having all coxae shining black and contrasting strongly with the yellow legs, though this color difference may be unreliable, and in having the cerci narrowly acuminate on the distal third, even more strikingly so than figured by Cole (1919, fig. 28). The form of the cerci, if a consistent character, will distinguish this species from its American congeners, which have the cerci more or less acute (cf. Cole, 1919, figs. 27b, 32a) but not acuminate.

ACROCERA STEYSKALI Sabrosky

(= *A. bulla* of authors, not Westwood)

The identity of *Acrocera bulla* Westwood was discussed by Sabrosky (1944), and the name *steyskali* proposed for the species with second vein present that had been identified by American authors as *bulla*. The available material at the time came from the northeastern states. In the examination of western specimens, however, the conclusion is inescapable that this is widely distributed across northern United States and Canada and in the West, probably a species of the Canadian zone. The examples cited here could not be distinguished from northern and eastern representatives.

It must be pointed out that the prior name for the species may be *Acrocera melanderi* (*A. bulla* var. *melanderi* Cole, 1919, p. 55, described from Gallatin County, Mont.). Until the type of *melanderi* can be studied, however, it seems safest to avoid possible error by continuing to use the name *steyskali*.

As usual, there is considerable variation in the extent of the color, especially from the male pattern shown in figure 1 of Sabrosky (1944), but the fundamental pattern remains the same. In some specimens, there is a basal black fascia on tergite IV, and in most of the present examples the yellow spots on tergite II are much more extensive, the pattern thus resembling that of the third tergite. In the females, the second tergite may be entirely black, and the yellow spots on tergite III greatly reduced in size. One consistent feature is that the venter of the abdomen is the predominantly dark brown to blackish type (fig. 2a of Sabrosky, 1944).

The distribution records cited here are interesting in that they highlight the difficulty of working with this uncommon family. The 14 specimens represent 13 localities and 11 states and provinces.

Material examined (including some specimens recorded by Cole, 1919, pp. 54-55, as *bulla*).—Fourteen specimens. ALBERTA: Male, Medicine Hat, October 1911 (J. R. Malloch) [USNM]. ARIZONA: Male, Williams, June 7, (H. S. Barber) [USNM]. CALIFORNIA: Male, Tahoe, July 1925 (F. X. Williams) [Calif. Acad. Sci.]. GEORGIA: Female, Blood Mt., August 30, 1945 (P. W. Fattig) [Emery Univ. Collection]. MAINE: Female, (Osten Sacken), recorded as *bulla* by Johnson (1915, Psyche 22: 200); male, York, September 4, 1923 (H. C. Fall) [MCZ]. MASSACHUSETTS: Female, Southbridge, July 3, 1913, recorded as *bulla* by Johnson (l. c.) [MCZ]. MICHIGAN: Male, female, Douglas Lake, Cheboygan County, July 20, 24, 1931 [C. H. Martin Collection]. NEW HAMPSHIRE: Female, West Milton, August 4, 1925 (H. C. Fall) [MCZ]; male, Franconia (Mrs. Slosson) [USNM]. NEW YORK: Male, Big Indian Valley, Catskill Mts. [USNM]. OREGON: Female, Corvallis, August 18 (F. H. Lathrop), recorded as *bulla* var. *melanderi* by Cole (1919, p. 56) [USNM]. WASHINGTON: Female, Signal Peak, July 4, 1930 (A. R. Rolfs) [USNM].

ACROCERA BAKERI Coquillett

Acrocera bakeri Coquillett, 1904, Invertebrata Pacifica, v. 1, p. 23. (Nevada.)

Cole saw only the female holotype, from Nevada, and he has given us an excellent and very recognizable figure (1919, fig. 34). The high proportion of orange-yellow area on the dorsum of the abdomen reminds one at first glance of the male sex of *obsoleta* and *unguiculata*.

In the western material before me, there are obviously two quite different species of females (*steyskali* and *bakeri*), but the males of the two are superficially similar and both stood in collections under *bulla*. It is not easy to state the difference in words, but a comparison of figures will illustrate the two types of color patterns on the abdomen. In Sabrosky (1944), figure 1 is the male of *steyskali*, subject to some variation as has already been noted. The specimens that I believe to be the males of *bakeri* have a pattern like that shown in figure 3a, with the median black triangles not reaching half the length of the segment and very wide at the base. As in *steyskali*, the basal black fasciae may or may not be complete. Regardless of the variation in each, the fundamental difference in pattern (cf. figs. 1 and 3a) is maintained.

A lone male, Huachuca Mts. Ariz. [USNM], seems to belong here, but it differs somewhat in having only small, round, median spots on tergites III and IV. It is possible that this is the male of an undescribed species, or perhaps of *arizonensis*. However, the male from the Santa Cruz Mts., Calif., is intermediate, and I have accordingly accepted the Huachuca specimen as within the limits of variation. In both of these males, the constriction of the spots makes the abdomen even more predominantly bright orange, resembling the female.

It is perhaps noteworthy that the only available material of *bakeri* is from the Far West. Whether this is significant should be checked further as additional material becomes known.

The males are small, ranging from 2-3.5 mm. in length, while the females are 3-5 mm.

Material examined.—Nine specimens. ARIZONA: Female, South Rim of Grand Canyon, June 26, 1930 (R. L. Usinger) [G. E. Bohart Collection]; male, Huachuca Mts. [USNM]. CALIFORNIA: Female, Alpine Creek, Tahoe, July 19, 1915 (E. P. Van Duzee) [F. R. Cole Collection]; male, Berkeley, September 21, 1931; male, Leona Heights, Oakland County, August 5, 1927 (R. L. Usinger); male, Convict Creek, Mono County, alt. 9,000 ft., August 9, 1937 (R. M. & G. E. Bohart) [G. E. Bohart Collection]; male, Pom Mts., October 27 (H. C. Fall) [MCZ]; male, Santa Cruz Mts.; male, Los Angeles County (Coquillett), recorded as *bulla* by Cole (1919, p. 59) [USNM].

ACROCERA BIMACULATA Loew

A number of additional specimens have been seen, and as remarked in a previous discussion (Sabrosky, 1944, p. 403), all are females. Since that paper was prepared, I have also examined the two cotypes in the Museum of Comparative Zoology, and both are females. Loew apparently misinterpreted one in saying that he was describing the species from both sexes.

The consistency of the character of the apical rudiment of the second vein is indeed interesting. If only one or a few such specimens were known, the presence of the stub might easily have been interpreted as an aberrant condition and scarcely tenable as a specific criterion.

Additional records.—Thirteen specimens, all females. MARYLAND: Jackson's Island, August 31, 1902 (H. S. Barber); Plummer's Island, May 8, 1915 (H. S. Barber) and May 21, 1916 (R. C. Shannon) [USNM]. MICHIGAN: North Branch, Lapeer

County, September 3, 1944 (G. Steyskal) [Steyskal Collection]. NEW JERSEY: Garrett Mts., September 1 [AMNH]. NEW YORK: West Point, June 3, 1911 (Wm. T. Davis) [USNM]; New York City, May 30, 1940 (C. H. Curran) [AMNH]; Ithaca, July 1-7 (N. Banks) [MCZ]. PENNSYLVANIA: "Pa" (J. M. Aldrich) [USNM]; Delaware County [MCZ]; Mount Airy, June 23, 1930 [MCZ]. QUEBEC: Montreal [AMNH]; Lewis County [MCZ].

ACROCERA spp. OF GROUP III

Although a number of western specimens have been seen since the 1944 paper was written, as well as additional material from the Eastern States, the status of some of the species in this group is still confused, if there actually are several species. The variation is so overlapping that the identities are obscured, the venter of the abdomen is frequently in poor condition (especially in females), and it is rare to find more than one specimen from a locality. In some cases, it seems hopeless to settle the problems until we are fortunate enough to collect long series, such as have been found on several occasions in *Ogcodes* and *Eulonchus*. It is hoped that sufficient detail has been given so that future workers can assign the specimens properly when the key to the problem is discovered.

ACROCERA FASCIATA Wiedemann

The correct application of this name is a matter of some doubt. In my revision of the genus (1944), I applied it to an eastern species with predomiantly black venter, after having seen such material determined as *fasciata* by Johnson and Cole. However, in material recently sent me from the Museum of Comparative Zoology were several specimens determined by Johnson as *fasciata* which had the predominantly yellow type of venter (including two reared from *Lycosa stonei* by T. H. Montgomery, and recorded as *fasciata* by Johnson, 1904). This is the form later described as *A. hungerfordi* (Sabrosky, 1944, p. 406), but herein called *hubbardi* (q. v.).

Although it now appears that most of the published references belong to *hubbardi* rather than to *fasciata* as restricted by Sabrosky (1944) on the basis of determined material then available to him, no useful purpose would be served at this time in reversing the concepts. *Fasciata* of authors was a mixture of two species, and the important thing now is that the two be carefully distinguished and the literature be clarified as far as possible.

Acrocera fasciata Wiedemann, as restricted by Sabrosky, 1944. Venter of the type figured by Sabrosky, 1944, fig. 2a; male dorsum, Sabrosky, 1944, fig. 2; female dorsum, Cole, 1919, fig. 35a.

A. fasciata; Emerton, 1890, Psyche 5: 404, fig. Bred from *Amaurobius sylvestris*. The figure, a side view of the male, shows a black venter and narrow basal black band on the dorsum of the fourth segment; I have no doubt that it should be referred here.

A. fasciata; Johnson, 1915, Psyche 22: 201, in part (the Framingham, Mass., male; record repeated by Sabrosky, 1944, p. 404).

A. nigrina; Johnson, 1915, pp. 201-202. Female sex; three of Johnson's specimens

were reported as *fasciata* by Sabrosky, 1944, p. 404; the fourth specimen (Quebec, Provancher) has now been examined and is the same.

A. fasciata; Cole, 1919, p. 51, males ,in part. Johnson records repeated.

A. nigrina; Cole, 1919, pp. 57-58, fig. 35a. Females. The Massachusetts specimen has been reexamined, and is *fasciata*.

A. fasciata; Sabrosky, 1944, pp. 403-405. Restricted, and the sexes associated.

For other notes on *Acrocera fasciata* of authors, see the discusison under *A. hubbardi*.

On the Cambridge, Mass., specimen recorded below, the median black triangle on tergite IV is not connected with the anterolateral spots. On the Quebec specimen, the median triangles on both tergites III and IV are separate, and although this is an extreme variation, I believe that the specimen may be recorded as an atypical example of *fasciata*. The male "*Acrocera* sp." described by Sabrosky (1944, p. 409) may likewise be an extremely atypical *fasciata*.

Additional records.—Seven specimens. CONNECTICUT: Female, Colebrook, June 23, 1914 (C. G. Hewitt) [Canad. Natl. Collection]. MASSACHUSETTS: Male, Cambridge, May 16, 1938, bred from *Amaurobius bennetti* (C. H. Paige) [MCZ]; female, "Mass.," June 10, 1886 (J. G. Jack) [MCZ]. NEW JERSEY: Female, Palisades, May 25, 1913 (G. P. Engelhardt) [USNM, det. by Johnson as *nigrina*]. PENNSYLVANIA: Male, Spring Brook, June 19, 1945 [USNM]. QUEBEC: Male, Laniel, June 15, 1931 (M. B. Dunn) [Canad. Natl. Collection]; female, Quebec (Provancher) [MCZ, det. Cole as *nigrina*].

ACROCERA CONVEXA Cole

Acrocera convexa Cole, 1919, Amer. Ent. Soc. Trans. 45:53. (California.)

The male holotype has been studied, and was found to be correctly interpreted by Sabrosky (1944). Cole has given an excellent figure of the species (1919, fig. 29, 29a). Besides the type, I have seen one male and three females of the species, all of which have a conspicuously bright-orange abdomen. The male has a median black triangle only on tergite II, and the females show a greater amount of black in the anterolateral angles of the tergites than do the males, but otherwise they have almost identically the pattern figured by Cole. The abdominal sternites are broadly yellow on the midportion (Sabrosky, 1944, fig. 4a), though with less yellow than in some species, the cerci of the female are of the short acute type figured by Cole (fig. 27b), and the male abdomen is apically indented like that of *obsoleta* (Cole, fig. 36b).

The relation of *convexa* to the form that I have tentatively identified as *obsoleta* V. d. W. is problematical. It is possible that the former represents merely a color variant with extreme reduction in the amount of black on the abdomen. Until something more definite can be found out, however, it is best to accord separate status to *convexa* and thus preserve its identity in the literature.

Material examined.—ALBERTA: Male, Medicine Hat, August 7, 1929 (J. H. Pepper) [Canad. Natl. Collection]. BRITISH COLUMBIA: Female, Glacier, August 8, 1904 [Canad. Natl. Collection]. SOUTH DAKOTA: Female, Brookings (J. M. Aldrich) [USNM]. UTAH: Female, Salt Lake (K. M. Pack) [USNM].

ACROCERA HUBBARDI Cole

Acrocera hubbardi Cole, 1919, Amer. Ent. Soc. Trans. 45:58, fig. 31. (Arizona.)

Acrocera hungerfordi Sabrosky, 1944, Amer. Midl. Nat. 31: 406, figs. 3, 3a. (Michigan, Pennsylvania.) New synonym.

A careful study of the type and paratype of *A. hubbardi*, both females, disclosed that the venter of the abdomen is not the dark type with narrow yellow fasciae along the posterior margins of the sternites, as figured by Cole (fig. 31) and accepted by Sabrosky (1944, p. 405), though it is somewhat discolored and gives that impression. On the contrary, the sternites are broadly yellow mesally, of the type shown in figure 4a of Sabrosky (1944), though the yellow areas are not as extensive. As a result of the misinterpretation of the ventral pattern, the name *hungerfordi* must be relegated to synonymy.

The writer neglected to mention in the original description of *hungerfordi* that the cerci are not long acute as in *fasciata* but are short acute, ending even more abruptly than in figure 27b of Cole (1919). This character is particularly useful when the venter of the specimen is not in good condition (as it seldom is), and a consequent misinterpretation of the first part of couplet 8 would lead the reader to believe that he had a variant of *A. fasciata*.

The variation in the amount of yellow on the abdomen of the females, especially on the second tergite, continues to cause considerable difficulty in distinguishing that sex. Some of them are probably included in the records cited merely as "*obsoleta-unguiculata* complex."

The following summary is necessary to clarify the relation of *hubbardi* to *fasciata* of authors:

Acrocera hubbardi Cole. Venter of the type figured by Sabrosky, 1944, fig. 4a; male dorsum, Sabrosky, fig. 3a; female dorsum, Sabrosky, fig. 3, though some variants have been seen with the yellow on the second segment approaching that of fig. 4.

A. fasciata; Montgomery, 1903, Acad. Nat. Sci. Phila. Proc., p. 68, bred from *Lycosa stonei*. These specimens, a male and a female, are in the Museum of Comparative Zoology and have recently been examined.

A. fasciata; Johnson, 1904, pp. 17-18, in part. Repeats data from Montgomery. A specimen from Algonquin, Ill., determined as *fasciata* by Johnson [MCZ], is presumably the northern Illinois specimen referred to by Johnson. It is a small male of *hubbardi*.

A. hubbardi Cole, 1919. Two females, Santa Rita Mts., Ariz.

A. hungerfordi Sabrosky, 1944. Description and records.

Additional records.—ARKANSAS: Male, Berryville, August 1938 (Christina Winton) [MCZ]. ILLINOIS: Male, Algonquin [MCZ]. MICHIGAN: Female, Ocqueoc Falls, Presque Isle County, August 14, 1928 (F. E. Lyman) [Kans. Univ.]. PENNSYLVANIA: Male, female, Philadelphia, bred from *Lycosa stonei* [MCZ].

ACROCERA UNGUICULATA Westwood

For a discussion of the possible identity of this species and *obsoleta* V. d. W., see the latter name. I am unable to separate the females satisfactorily, and it is possible that the males also fall within the same range of variation.

For the present, I shall continue to record as *unguiculata* those males of the type figured by Cole (fig. 36, 36a).

The California male recorded below is atypical, and is cited here with considerable doubt.

Additional records.—CALIFORNIA: Male, San Francisco, July 1922 (F. X. Williams) [Calif. Acad. Sci.]. MICHIGAN: Male, Cheboygan County, July 18, 1938 (Melvin Griffith) [Kans. Univ.].

ACROCERA sp. (obsoleta Van der Wulp (?))

The males of this species have a distinctive appearance, though it is still possible that a good series of specimens would show intergradation with *A. unguiculata* on the one hand and *A. convexa* on the other. As more material became known, it was impossible to separate satisfactorily the females of *obsoleta* and *unguiculata*. It seems best for the present, therefore, to record the females only as belonging to the *obsoleta-ungiuculata* complex. For that matter, the females of *hubbardi* (= *hungerfordi*) may also vary sufficiently to be confused here, at least in some cases, though generally the females of the former two are much brighter, with broad orange bands on tergites II to IV. The orange fasciae on III and IV in *hubbardi* are narrower, and on the second tergite reduced to two small spots or absent altogether, resulting in a relatively dark habitus.

The records now available indicate that the species is widely distributed across northern and western United States and Canada.

Additional records.—All males. ALBERTA: Cooking Lake, July 11, 1937 (F. O. Morrison) [F. R. Cole Collection]. CALIFORNIA: Davis, July 1935 [G. E. Bohart Collection]; Sears Point, Marin County, May 28, 1931 (E. P. Van Duzee) [Calif. Acad. Sci.] MICHIGAN: Cheboygan County, July 22, 1941 (H. B. Hungerford) [Kans. Univ.], and July 14, 1931 (James Brennan) [C. H. Martin Collection]

ACROCERA females, OBSOLETA-UNGUICULATA COMPLEX

Additional records.—Nineteen specimens, all females. ALBERTA: Five, Wabamun, July 13, 1939 (E. H. Strickland) [F. R. Cole Collection]. BRITISH COLUMBIA: Terrace (Mrs. Hippisley) [MCZ]. CALIFORNIA: Three, Crystal Lakes, San Mateo County, June 25, 1916 (E P. Van Duzee) [MCZ, and F. R. Cole Collection]; Santa Cruz County, June 9, 1917 (W. M. Gifford); Oakland, August 1905 (E. C. Van Dyke); Sisson, July 25, 1918 (E. P. Van Duzee) [Calif. Acad. Sci.]; two, Davis, July 1935 [G. E. Bohart Collection]; Monterey County, September 22, 1903 (Coleman) [USNM]; Huichica Creek, Napa County, June 23, 1938 (J. W. Tilden) [AMNH]. COLORADO: Denver, July 12, 1903 (M. C. Van Duzee) [Calif. Acad. Sci.] NEW BRUNSWICK: Sackville, July 15, 1942 (G. M. Stirrett) [Canad. Natl. Collection]. WASHINGTON: Pullman, July 10, 1933 [R. H. Painter Collection].

Group IV.—ACROCERA spp. WITH REDUCED VENATION

Only five specimens of this group were available at the time of my previous study (1944). With additional material, the total is now six males and 13 females. There appear to be five species of each sex but with little or no indication as to which, if any, should be associated. If variation should be as great as some specimens suggest, there may even be fewer than five species of

each sex. Under such conditions of uncertainty and limited material, it seems highly inadvisable to attempt to name them. The available specimens with their characteristics are listed here for the convenience of future workers who may have an opportunity to solve the problems of species in this portion of the genus.

It may be noted that most of the specimens in this group are from 2-3.5 mm. long, easily the smallest acrocerids known to the writer.

The characteristic yellow abdominal spots referred to for the sake of brevity as semilunar are like those on tergites II and III in Sabrosky (1944, fig. 3a), or like tergites III and IV of figure 5 when the black area is more extensive. In a few specimens of Group IV, the basal black fascia is extremely narrow, and sometimes is discontinuous, with a median spot not or only weakly connected with the lateral areas of infuscation.

FEMALES *(arranged in order from darkest to brightest species)*

1. Thorax entirely black; first three abdominal tergites black, the fourth with a semilunar yellow spot. Framingham, Mass., 7-23-44 (C. A. Frost) [MCZ] (2 mm. long, the smallest acrocerid that I have seen); Neel Gap, Ga., 8-4-45 (P. W. Fattig) [Emory Univ. Coll.]

2. Thorax black; tergites I and II black, III and IV each with broad semilunar yellow spot; 3-3.5 mm. Iowa City, Iowa, July 21 (Wickham); Washington, D. C., 8-25-43 (W. S. Fisher) [USNM]; Fort Washington, Md., 5-26-1896 (C. W. Johnson) [MCZ]; Manistee, Mich., 7-8-41 (Sabrosky) [Sabrosky Coll.]; Agricultural College, Mich., 8-26-1891 (G. C. Davis) [Mich. State Coll.].

3. Thorax black; tergite I black, II and III with semilunar yellow spots, IV predominantly yellow with a median black spot not connected with the anterolateral spots; 3-5 mm. California, 9-14-30 [G. E. Bohart Coll.]; Lehigh Gap, Pa., 7-10-1897 (C. W. Johnson) [MCZ]; Montesano, Wash., 7-23-31 (R. H. Beamer) [Kans. Univ.].

4. Thorax black; abdomen predominantly orange yellow, tergite I black, the rest of the abdomen like that of figure 6 of Sabrosky (1944). College Station, Tex., 4-8-43 (H. J. Reinhard) [Texas A & M Col. Coll.]; Austin, Tex., 5-1-23 (Eugenia Rountree) [R. H. Painter Coll.].

MALES *(numbered like females where a tentative association is made)*

2. Pattern similar to Iowa specimen, the basal black fascia on tergite IV almost discontinuous. White Heath, Ill., 8-27-39 (J. C. Dirks) [USNM].

3. Virtually the same pattern, on tergite IV the median black spot weakly connected with the anterolateral spots. Santa Cruz Mts., Calif. [USNM].

5. Thorax and abdomen like figure 7 of Sabrosky (1944), differing only in the minor points of scutellum entirely black, the black midline on tergite II slightly broader, and the median black triangle on tergite III discontinuous with the anterolateral black areas. Wabamun, Alberta, 6-28-36 (E. H. Strickland) [F. R. Cole Coll.].

(? = *Acrocera bulla* Westw. of Sabrosky, 1944.)

5. *Acrocera bulla* of Sabrosky (1944, pp. 411-412). The two males cited there have the same color pattern as female No. 5, and may be the same species.

6. Thorax black; abdomen in poor condition but apparently chiefly yellow, like that of figure 6 of Sabrosky (1944) but without median spots on tergites III and IV. Corvallis, Oreg., 8-14-31 [USNM].

7. *Acrocera flaveola* Sabrosky. Cf. figure 6, Sabrosky (1944). No other specimens have been seen that come close to the distinctive pattern of this male.

OGCODES Latreille

Monobasic. Type, *Musca gibbosa* L. (as *Syrphus gibbosus* F.).[2]

The species of *Ogcodes* are quite similar in appearance, and the apparent lack of good taxonomic characters has in the past caused considerable confusion and misidentification. The difficulties were discussed in detail by Sabrosky (1944), when the classification of the genus was greatly clarified by demonstration of the sexual dimorphism with respect to the color pattern of the abdomen, and of the importance of the presence or absence of an evident albeit weak vein M_1 in the wing.

As in *Acrocera*, a large amount of western material has made it possible to extend the study, and a complete key can now be offered. At several points, the conclusions are still open to further investigation, especially on the relationship and relative status of the eastern and western populations of *pallidipennis*, and the same for the *eugonatus* complex. Additional light has been

---

2 *Ogcodes* Latreille (1796)was proposed without mention of any species. The first species to be associated with the name, and hence the genotype, was *Syrphus gibbosus* F. (i. e., *Musca gibbosa* L.), by Latreille (1804, Tabl. Méthod., in Nouv. Dict. d'Hist. Nat., v. 24, p. 200; [1804?] Hist. Nat. Crust. Ins., v. 3, p. 432).

A misidentified genotype seems to be involved here, however, for European authorities are generally agreed that *gibbosus* in the sense of Latreille was not *gibbosus* of Fabricius and Linnaeus but was the species now known as *zonatus* Erichson. Inasmuch as both *gibbosus* Linnaeus and *zonatus* are unquestionably congeneric, there is no particular point in raising the issue and I accept the stated genotype.

The emended form, *Oncodes*, was first suggested by Meigen (1822, Syst. Beschr., v. 3, 99) and is quite often cited, but I see no reason for rejecting the original spelling.

shed on some of these problems by the study of the male genitalia, as discussed below.

In 1944, I had 157 specimens of the genus for study, by far the largest number brought together up to that time. In the present paper, over 370 additional specimens of *Ogcodes* are recorded.

Male genitalia.—Though occasional reference has been made to the fact that two species had different genitalia, there are no published figures or statements that make clear the differences that exist. Males of all species recognized here have been dissected during this study, and the status of each species analyzed in those terms as well as by the other criteria normally used. The most distinctive characters lie in the form of the ejaculatory apodeme, and in the shape of the distal end of the aedeagus as seen in side view or profile. The latter can often be seen without dissection, if the aedeagus is even slightly extruded.

The ejaculatory apodeme is composed of a flattened median plate and two lateral arms or "wings" which are closely connected to the base of the median plate and appear to be fused with it. The median plate by itself has been called the ejaculatory apodeme, and the "wings" lateral apodemes, but the three form essentially one structure and are so referred to here. For convenience in the descriptions, the "wing spread" is the distance between the outermost points of the "wings" (figs. 10-12), the length of the apodeme is the over-all length in anterior or end view (figs. 10-12), and the length and width of the median plate are measured in side view (figs. 13-15), the length being the distance from the apex of the median plate up to but not including the base of the "wings." The last-named proportion is the least reliable, possibly due in part to the difficulty of exact measurement of the length in side view.

Extreme care must be taken in removing the genitalia to secure the ejaculatory apodeme, especially in species in which the latter is large and well-developed. A hooked needle, inserted between the sclerites and well into the abdomen, will usually bring it out with the rest of the genitalia; if one pulls on the genitalia directly, the connection with the apodeme will sometimes break and the apodeme will remain within the abdomen, partly concealed by a pear-shaped ejaculatory sac. In any case, some dexterity will be required to remove the genitalia without spoiling the weak, inflated abdomen. This may usually be done fairly successfully by supporting the fly between the thumb and forefinger, puncturing in a number of places the intersegmental membranes surrounding the genitalia, inserting the hooked point of a fine pin, and tearing the genitalia loose by a gentle, twisting motion that avoids a straight pull on the weak abdomen.

The study revealed four distinct types of genitalia in the genus, based on the structure of the ejaculatory apodeme (*O. albiventris* is omitted here; the apodeme was broken in the only available male).

1. (Figs. 11, 14.) Apodeme strongly developed; median plate large, flattened throughout its length.—*pallidipennis* complex: *pallidipennis* (Loew), *pallidipennis*, dark western form (subspecies?), *dispar* (Macquart), *rufoabdominalis* Cole.

2. (Figs. 10, 13.) Apodeme strongly developed; median plate large, broadly expanded basally as figured, with the appearance of two broad cells.—*borealis* Cole.

3. (Figs. 12, 15.) Apodeme strongly developed; median plate large, broadly expanded basally as figured, but the subbasal cell narrowly triangular in shape.—*eugonatus* complex: *eugonatus* (Loew), *albicinctus* Cole, *melampus* (Loew).

4. Apodeme weakly developed, inconspicuous; the wing spread approximately equal to the greatest width of the aedeagus; median plate small, thickened throughout its length.—*colei* complex: *vittisternum*, n. sp., *colei*, n. sp., *shewelli*, n. sp., *floridensis*, n. sp.

It is interesting to note the correlation with characters hitherto used for specific distinctions. The species with vein M_1 absent (first used as the primary criterion in the genus by Sabrosky, 1944) fall in Group 3 (*albiventris*, the fourth species lacking that vein, cannot be placed in a group because the apodeme is unknown). The species in Groups 1, 2, and 4 all have vein M_1 present, in various stages of development.

The four new species—*vittisternum*, *colei*, *shewelli*, and *floridensis*—form a small group of apparently closely related species. Vein M_1 is present in all though sometimes weak, the dorsum of the abdomen is variously patterned, and the thoracic and abdominal hairs, particularly the latter, are notably longer than usual in the genus. The male genitalia of the four species proved to be similar, and to be distinct from other types in the genus. The genitalia are smaller in proportion to the size of the abdomen than in other *Ogcodes*, the aedeagus is prolonged distally into a fingerlike projection (cf. figs. 18 to 20), and the ejaculatory apodeme is small and relatively inconspicuous.

KEY TO THE AMERICAN SPECIES OF OGCODES

MALES

1. Vein M_1 (= f_1 of Cole, 1919) rather completely developed as in figure 2 of Cole, usually attached basally to the stub of r-m cross vein (= x of Cole) and extending nearly to the margin of the wing, occasionally the cross vein absent and vein M_1 pale and weak, though still present throughout its length.... 2

   Vein M_1 absent, or at most only a short distal portion very faintly and weakly indicated, appearing like a slight crease in the wing 10

(Vein M_1 present)

2. Ground color of the thorax yellow to dark orange, with or without indications of one to three stripes on the disk of the mesonotum ....*dispar* (Macquart)

   Thorax chiefly black, the disk of the mesonotum entirely so 3

3. Dorsum of the abdomen with the common *Ogcodes* pattern of broadly brown to black tergites with regular, white to yellowish-white fasciae along their posterior margins (typified by Cole, 1919, fig. 40); hair on the mesonotum and abdomen short, the longest on the dorsum of the abdomen being much shorter than the length of the hind metatarsus; genitalia with large and well-developed ejaculatory apodeme 4

   Dorsum of the abdomen variously patterned, but never with regular, parallel-sided fasciae as in the preceding; mesonotal and dorsal abdominal hair long (except in *rufoabdominalis*), the longest hairs on the abdomen usually subequal to or longer than the hind metatarsus; genitalia with small and inconspicuous ejaculatory apodeme 6

4. Abdominal sternites II-V broadly black, with much narrower yellow fasciae

along the posterior margins, the black area equally broad both mesally and laterally (as in fig. 2a, Sabrosky, 1944); genitalia with the median plate of the ejaculatory apodeme basally expanded (fig. 10) ....*borealis* Cole

Abdominal sternites II-V chiefly whitish yellow, the basal black fasciae quite narrow mesad but almost as broad as the sternite laterad, thus giving the yellow area on each sternite an anteriorly convex margin (as in fig. 4a, Sabrosky, (1944); genitalia with the median plate of the ejaculatory apodeme flattened throughout (fig. 11) 5

5. Humeri, postalar calli and scutellum entirely or partly whitish yellow to reddish; basal fasciae of the tergites almost always reddish brown; general habitus brown (eastern) ....*pallidipennis* (Loew)

Humeri, postalar calli and scutellum black; the broad basal black fasciae of the abdominal tergites black; general habitus black (western) ....western subspecies (?) of *pallidipennis*

6. Dorsum of the abdomen reddish orange with a median row of broadly triangular, brown-black spots (Cole, 1919, fig. 43); hair on the abdomen short, much less than the length of the hind metatarsus ....*rufoabdominalis* Cole

Abdomen not so marked, or if with a median row of triangular spots, the hair on the abdomen is long and the ground color of the abdomen is bright yellow to whitish yellow; hair on the abdomen relatively long, the longest subequal to or longer than the hind metatarsus 7

7. Venter of the abdomen with three rows of black-brown spots, composed of a large subquadrate median spot and two small lateral spots on each sternite except the first, which is entirely black (fig. 2); pattern of the dorsum as in figure 3 ....*vittisternum*, new species

Venter not so marked, no median row of subquadrate black spots; dorsum not as in figure 3 8

8. Second abdominal tergite entirely yellow, the third and fourth with three brown spots, the fifth and sixth almost entirely shining brown (fig. 4) ....*floridensis*, new species

Second to fourth tergite each with a large median spot 9

9. Dorsum of the abdomen as in figure 6; the second to fourth tergites each with a median triangular black spot; femora and tibiae bright yellow ....*shewelli*, new species

Dorsum as in figure 7, the second to fourth tergites each with a broad subquadrate black spot; basal portion of all femora infuscated, up to about three-fourths of the length ....*colei*, new species

(Vein M_1 absent)

10. Dorsum of the abdomen predominantly yellow to whitish, with striking pattern of long narrow spots (fig. 9); thorax and abdomen with unusually long hair, that on the latter as long as the hind metatarsus ....*albiventris* (Johnson)

Dorsum with the common *Ogcodes* pattern of broadly brown to black tergites with regular white to yellowish-white fasciae along their posterior margins; body hairs short, much less than the length of the hind metatarsus 11

11. Legs black, at most the knees narrowly orange (far western) ..*melampus* (Loew)

Legs partly yellow, often strongly yellow and black marked, occasionally predominantly infuscated in northern specimens 12

12. Wide whitish-yellow bands on the posterior margin of the abdominal tergites, one-half to two-thirds the length of a tergite (fig. 42 in Cole, 1919) (northwestern) ....*albicinctus* Cole (= *marginatus* Cole, preoccupied)

Abdominal bands narrower, about one-third or less the length of a tergite (approximately like fig. 40 in Cole, 1919, as far as abdomen alone is concerned); (eastern) ....*eugonatus* (Loew)

Females.—No reliable characters have been found for distinguishing the females of a number of the species, and a key is not presented for that sex. The known females can be identified approximately by running them as far as possible in the key to males.

The first couplet will divide them into the two major groups in the genus, based on wing venation. Beyond that, the females of *dispar* and *rufoabdominalis* are easily spotted by their brighter color. *O. borealis* may be recognized if the venter of the abdomen is in good condition, though some dark specimens of *pallidipennis* are quite similar and it is best to rely chiefly on males.

The female sex is unknown in *vittisternum, floridensis, shewelli, colei,* and *albiventris*. The males of all these species have the dorsum of the abdomen yellow and black patterned, and the hair on the disk of the abdomen unusually long. If the females have corresponding characteristics, they might thus be distinguished from other species in the genus.

The chief difficulty in identifying females will come in trying to distinguish between closely related species in the two groups (based on male genitalia) that I have called the *eugonatus* complex and the *pallidipennis* complex. Without associated males, it will be difficult to determine females from the West and Northwest, though in eastern United States one will be safe in calling them *eugonatus* and *pallidipennis*.

OGCODES DISPAR (Macquart)

Oncodes dispar Macquart, 1855, Dipt. exot., Suppl. 5:67. (Maryland.)
Ogcodes vittatus Johnson, 1923, Psyche 30: 50-51. (New Jersey.) New synonym.

Sabrosky (1944) recognized both *vittatus* and *dispar,* though admitting that the distinctions between the two were not clear-cut in the small amount of material that had been studied. From the specimens examined since that time, and espeically from a pair taken in copula, it seems clear that the males are typically bright yellow, but the females are usually darker and either show three brownish vittae or suggestions of such vittae. The females differ considerably in the distinctness of the stripes, but at least a trace is evident in all. The specimens of *O. dispar* in C. W. Johnson's Collection [MCZ], and upon which he doubtless based his conception of the species, were all bright yellow males. His *vittatus* was apparently based upon a female in which the mesonotal stripes were especially distinct.

The male genitalia proved to be virtually the same as those of *pallidipennis* (cf. figs. 11, 14, 17). The ejaculatory apodeme and its wings are large and strong, with the same appearance as *pallidipennis* in both side and end view except that the wings are more curved and the whole might be described as umbrella-shaped. In end view the length of the apodeme is only slightly greater than the "wing spread," as 30:27, but there is apparently some variation in all species in the bending of the wings, and hence in this proportion. The "wing spread" is over twice the greatest breadth of the aedeagus. In side

view, the median plate is slightly over twice as long as broad, as 13:6. The aedeagus is approximately the same as that figured for *pallidipennis*, in both side and top views.

The male from College Station, recorded by Sabrosky (1944, p. 391) as *vittatus*, was reexamined in this study and appears to be an unusually dark individual showing the same mesonotal stripes found in the female.

The records listed below add materially to the known distribution of this species, which appears to be widespread in the eastern and southeastern states, though uncommon.

New records.—Sixteen specimens. DISTRICT OF COLUMBIA: Male, Washington, June 1922 (M. T. Van Horn) [USNM]. ILLINOIS: Male, Cave-in-Rock State Park, July 23, 1938 (Burks and Boesel) [Ill. Nat. Hist. Surv.]. MARYLAND: Female, Hancock, July 3, 1916 (F. R. Cole) [Cole Collection]; male, College Park, 1914 [MCZ]; six (4♂, 2♀), Plummer's Island, August 9, 1902 (Barber & Schwarz), June 4, 1905 (E. A. Schwarz), June 13, 1905 (D. H. Clemons), May 30, 1911 (H. S. Barber), June 19, and August 25, 1912, pair taken in copula (E. A. Schwarz) [USNM]. NEW JERSEY: Male, Ramsey, June 29 (W. J. Gertsch) [AMNH]. PENNSYLVANIA: Male, female, Spring Brook, July 12, 1945 [USNM]; female, Morrisville, September 3, 1924 (D. H. Blake) [USNM]; male, Delaware County [MCZ]. VIRGINIA: Male, Suffolk, June 11, 1895 [MCZ].

OGCODES BOREALIS Cole

Figs. 10, 13, 16

In the 1944 revision, I placed *borealis* as a possible synonym of *pallidipennis*. No material had then been seen that could be referred to *borealis* and permitted an evaluation of the color characters used in describing the species. However, a series from Alberta was made available through the kindness of Mr. G. E. Shewell, and from these specimens it is evident that the species is distinct, though very close to *pallidipennis*. It is possible that some of my previous determinations of the latter should really apply to *borealis*, but all of those that have been rechecked are typical *pallidipennis*. The latter is common throughout eastern United States and eastern Canada, but available specimens of *borealis* are few and chiefly northern.

In my previous key to the genus (1944, p. 388), *borealis* goes to couplet 5, second choice, but it is distinguished from *pallidipennis* by the characters used in the present key. Furthermore, in *borealis* the humeri, postalar calli and scutellum are black, rarely the first two inconspicuously yellow-tipped, the coxae are black in the males, partially yellow in the females, and the legs are otherwise yellow though the distal tarsal segments may be slightly browned. In *pallidipennis*, on the other hand, some or all of the humeri, postalar calli, and scutellum are often partly or entirely white, yellow, or orange yellow, especially in eastern specimens, and the legs are usually at least partially brown to black, especially the tibiae and tarsi of the females.

Male genitalia with large, well-developed ejaculatory apodeme; "wing spread" 1.7 times the greatest breadth of the aedeagus, but only two-thirds the length of the apodeme in end view because of the long median plate (fig.

10); median plate of the apodeme large, in side view one and one-half times as long as broad, broadly expanded on the basal half (fig. 13); distal end of the aedeagus in side view with a short thumblike projection before the apex (fig. 16).

In the series of *borealis* from Waterton, Alberta, the males are well preserved with abdomen fully distended, and they appear decidedly different from *pallidipennis* with their black thorax, entirely black coxae but otherwise all yellow legs, and distinct pattern on the venter of the abdomen, the sternites showing sharp lines of demarcation between the dark brown-black and the yellow areas. All the females, however, have the abdomen collapsed and shrunken (teneral or post-oviposition condition?), with the result that the color pattern of the venter is not so clear-cut. The females likewise show more yellow on the coxae, humeri, postalar calli and occasionally the scutellum, as well as considerable yellow below the wing base, though the lighter color no doubt depends in whole or in part on the condition of the specimens. At any rate, in their present condition, the females resemble *pallidipennis* much more than do the males. The habitus of the venter is a reliable criterion, but unless the abdomen is in fair to good condition, it may not be possible to interpret it correctly for individual specimens. In *pallidipennis,* and also in *eugonatus,* if the abdominal segments are slightly telescoped, the venter appears almost entirely whitish yellow, in sharp contrast to the dark brown of *borealis.*

It should be observed that vein M_1 is not as clearly evident in some *borealis* as it usually is in *pallidipennis,* but even though sometimes only a trace, the position of the vein never approaches the blank clarity of the wing of *eugonatus.* Most specimens of *borealis* will not be misinterpreted, but it may be worth while to note that in case of doubt, such specimens will run in the key to *eugonatus,* and the latter is easily distinguished by having the same predominantly yellow or whitish-yellow ventral habitus as *pallidipennis,* and distinctive black markings on the femora. One specimen of the dark western form of *pallidipennis* had the venter considerably infuscated, and was thus at first mistaken for *borealis,* though the yellow fasciae on both dorsum and venter were broad and the specimen would normally be associated with *pallidipennis.* The male genitalia proved the latter to be correct.

As in the other species of *Ogcodes,* the yellow to whitish fasciae on the posterior margins of the tergites are broader in the males than in the females. In the males, the fasciae are narrower than in *pallidipennis,* being only a little over one-fifth the length of a tergite at their widest on segment 4, and less on the others; in *pallidipennis,* on the other hand, the widest band occupies nearly one-third the length of its tergite, and the others are proportionately broader than in *borealis,* the result being that the fasciae stand out more distinctly.

Material examined.—Seventeen specimens. ALBERTA: Twelve (6♂, 6♀), Waterton, July 8-14, 1923 (H. L. Seamans) [Canad. Natl. Collection]. MANITOBA: Two (♂, ♀), Berens River, July 5-9, 1938 (W. J. Brown) [Canad. Natl. Collection]. MARYLAND: Male, Plummer's Island, August 23, 1919 (H. S. Barber) [USNM]. NEW YORK: Male, McLean, June 30, 1921 (R. C. Shannon) [USNM]. SASKATCHEWAN: Male, Waskesia, July 19, 1930 (K. M. King) [Canad. Natl. Collection].

OGCODES PALLIDIPENNIS (Loew)

A fine series of 25 specimens received from Dr. Henry Dietrich, of Cornell University, has permitted a reexamination of the synonymy suggested in the earlier revision (Sabrosky, 1944, pp. 392-394). The flies were clustering on apple twigs which were black with their eggs. In view of the extreme variability in size and color in this family, it is especially interesting and important to see a large number of specimens collected at the same time and place under circumstances that make them virtually certain to be conspecific.

The present specmens fit very well into the analysis of the material available to me in 1944, which consisted of more specimens, but few from any one locality. Twenty-four are females, as against one male, a sex ratio which is not surprising since they were probably collected during or shortly after oviposition. The male is medium sized (5.25 mm. in length), and is somewhat paler in habitus than the females, with the humeri and postalar calli yellow, scutellum reddish yellow except for the extreme basal corners, and legs predominantly deep yellow. The wing membrane is hyaline, though the costa is black and the distal third of both costa and first longitudinal vein is thickened. The females range in size from 3.75 mm. to stout-bodied specimens of 7.5 mm. in length, with most of the specimens about 6 mm. In general, their habitus is darker than that of the male, partly because the yellow abdominal fasciae are narrower (a sexual character), and partly because the scutellum is usually reddish brown to pitch black, the legs (at least the dorsal and anterior surfaces) are consistently darker than in the males, and the wing membrane usually appears slightly browned, especially between R_1 and the heavy black costa. Most of the specimens would thus have been placed as *O. incultus* by former authors, and the male would have been called *O. costatus*, as pointed out by Sabrosky (1944).

The color pattern of the pleura is noteworthy in this series. Although the yellow areas were once suspected of being due to incomplete coloration (teneral) or to variation, the present long series shows a consistent pattern that deserves mention, especially because other very similar species have entirely black pleura. The pteropleura is entirely yellow, as well as the posteroventral fourth to third of the mesopleura and the upper fourth of the sternopleura. The latter is gray pollinose, the rest of the pleura highly shining. In the two palest specimens, nearly three-fourths of the mesopleura is yellow.

Compared with western specimens of what may be a subspecies, the males of the eastern *pallidipennis* stand out by their lighter color, with yellow to reddish-yellow humeral and postalar calli and scutellum (except in occasional northern specimens), and usually the dark portions of the abdominal tergites reddish brown rather than black. The yellowish-white fasciae on the hind margins of the abdominal tergites are regular in this species (cf. Cole, 1919, fig. 40), often nearly equal in width on tergites II-V, the widest fascia (on V) sometimes up to four-tenths the width of its tergite. The thoracic hairs are short and appressed, and those of the abdomen very short and naplike.

Vein M_1 is regularly brown and distinct, and there is almost always a stump of r-m cross vein present.

Male genitalia with large, well-developed ejaculatory apodeme; "wing spread" three times the greatest breadth of the aedeagus, but barely three-fourths the length of the apodeme in end view because of the long median plate (as in fig. 11, but the median plate slightly longer in proportion); median plate large, flattened, in side view slightly over twice as long as broad, the shape approximately that of figure 14; distal end of the aedeagus in side view as figured (fig. 17). The eastern and western forms differ so slightly in the shape and proportion of the ejaculatory apodeme that only one has been figured. A long series of dissections might show that even these slight differences are consistent, and would substantiate the recognition of the western population as a subspecies or perhaps even a species (cf. note under western form on the Los Angeles County, Calif., male).

Distribution.—Widespread and relatively common in eastern United States, and it therefore seems undesirable to detail the numerous records. To summarize, since the previous publication on the species (1944), 31 males and 49 females, besides a number unrecorded as to sex, have been seen from the following states and provinces: Arkansas, District of Columbia, Georgia, Indiana, Kansas, Maine, Manitoba, Maryland, Massachusetts, Minnesota, Missouri, New Brunswick, New Hampshire, New Jersey, New York, Ohio, Ontario, Pennsylvania, Texas, Vermont, Virginia, Wisconsin.

The following records of especial interest may be cited: Twenty-five (1♂, 24♀), Ithaca, N. Y., July 19, 1946, "clustered on apple twigs" (P. A. Readio) [Cornell Univ. Collection]; female, Ramsey, N. J., July 26, 1944, parasite of *Anyphaenella saltabunda* Htz. (W. J. Gertsch) [AMNH]; male, Port Stanley, Ontario, May 10, 1922 (G. J. Spencer) [AMNH], an early record for this far north, where most recorded specimens were collected in late June and July.

Seasonal distribution of the above material: April 5 (Victoria, Tex.) to July 27 (South Bristol, Maine), with six scattered specimens recorded on August 6, 26, 27, and September 14. The latest recorded individual was collected at Falls Church, Va., September 14, 1915 (G. M. Greene) [USNM].

Western subspecies (?) of OGCODES PALLIDIPENNIS (Loew)
Figs. 11, 14, 17

Ogcodes melampus (Loew). Cole, 1919, Amer. Ent. Soc. Trans. 45:61-62; Sabrosky, 1944, Amer. Midl. Nat. 31:391.

Ogcodes melampus (Loew) is actually a species of the *eugonatus* complex (vein M_1 absent)), as I recognized when I recently examined the type in the Museum of Comparative Zoology. It was misinterpreted by Sabrosky (1944), and also by Cole (1919), as evidenced by the determined specimens cited in the latter's revision.

The long series of western specimens before me appear much darker than the eastern *pallidipennis* and are accordingly segregated as probably a distinct form. Unfortunately, no character can be relied upon to separate the two. In male genitalia, wing venation, size, and dorsal and ventral abdominal pattern, eastern and western specimens are apparently identical. When the two series are placed side by side, the eastern forms are more brightly colored, as already pointed out, because the dark areas of the abdomen are reddish brown, the scutellum is conspicuously reddish to orange, the humeral and postalar calli are more or less so, the former often yellow, and the hair is usually pale yellowish. Western specimens, on the other hand, are much darker in habitus, the dark areas of the abdomen are usually black, the scutellum is black, the calli at most are dusky yellow at the tips and the hair is usually silvery white. These notes apply particularly to the males, for the eastern females are usually darker than the males, and sometime quite dark, so that the difference between them and the western females is not as great as between males from the two areas. It may be observed also that some of the larger western females have browned wings like the eastern form known as *incultus*. The color of the legs varies a good deal in both eastern and western specimens.

Male genitalia as figured (figs. 11, 14, 17) and as described for eastern *pallidipennis* except that the median plate is slightly longer, and thus in end view the length of the apodeme is approximately equal to the "wing spread." One of the males from Los Angeles County, Calif., which has a habitus typical of eastern *pallidipennis*, was dissected and found to have a "wing spread" of only 0.77 the length of the apodeme, approximately the same as that of the eastern form.

It seems possible, therefore, that here is a population which is too close to the eastern form to be regarded as specifically distinct, but which might well be considered a western subspecies characteristically darker than the typical form. However, some intermediate specimens have been seen from scattered areas in the West, and even a few western individuals that are fully as brightly colored as typical eastern *pallidipennis*, e. g., three males, Los Angeles County, Calif. (Coquillett) [USNM], determined by Coquillett as *O. costatus* (the name usually applied by authors to males of *pallidipennis*, cf. Sabrosky, 1944, pp. 392-393). As already pointed out, the genitalia of one of these males proved to be more like the eastern form than like dark western specimens.

It seems unwise to name that which cannot be adequately defined. It is always possible, of course, that further observations will show that the western form is entitled to some degree of recognition, and accordingly I have listed the records in detail for future reference if needed.

The record of this species being used by a crabronid to provision its nest in twigs (Oak Creek Canyon, Ariz., June 8, 1940) deserves special mention. Mr. G. E. Bohart, the collector, wrote that "this species of wasp was not seen to use any other species of fly." All 10 of the specimens submitted to me are

males, but the preponderance of this sex in collections of these flies is not necessarily unusual. Gerstaecker, in Germany, in 1856, observed a large assembly of *Ogcodes* and noted that the males were more active and flew much more than the females. If this is generally true, they would be more likely to attract hunting wasps. In Europe, a number of published observations have recorded that "a certain species of *Crabo* invariably selected *Ogcodes gibbosus* to store its burrows in the brambles" (Cole, 1919, p. 12).

Western material examined.—Eighty specimens.

(1) Typical *pallidipennis* habitus: CALIFORNIA: Four (3♂, 1♀), Los Angeles County (Coquillett) [USNM]. The female was identified by Coquillett as *pallidipennis*, a small male by Cole as *aedon*, and the two larger males by Coquillett as *costatus*.

(2) Dark form: ARIZONA: Male, Huachuca Mts., August 24, 1934 [USNM]; male, Sunnyside Canyon, Huachuca Mts., July 9, 1940 (E. E. Kenaga) [Kans. Univ.]; two males, Oak Creek Canyon, July 9, 1941 (R. H. Beamer) [Kans. Univ.]; 10 males, Oak Creek Canyon, June 8, 1940, "stored in twigs by a crabronid" (G. E. Bohart) [Bohart Collection]. BRITISH COLUMBIA: Female, London Hill Mine, Bear Lake, alt., 7,000 ft., July 21, 1903, "collected upon snow" (A. N. Caudell) [USNM]. CALIFORNIA: Male, Shasta County; three males, Humboldt County (E. C. Van Dyke); male, Mono Lake, July 21, 1911, referred to *O. marginatus* (now *albicinctus*) with some doubt by Cole (1919, p. 67); four (2♂, 2♀), Santa Cruz Mts., cited by Cole (1919, p. 62) under *O. melampus*; male, San Jacinto Mts., Strawberry Valley, July 12. 1912 (J. C. Bridwell); male, Saticoy (Stanley Flanders); female, Pasadena (J. M. Aldrich) [all USNM]; two males, Berkeley, August 30, 1919, recorded by Sabrosky (1944, p. 391) as *O. melampus* [Cornell Univ.]; male, Alviso, June 5, 1922 (E. O. Essig); male, female, Berkeley, September 15, 1915, and October 1914 (E. P. Van Duzee); male, Lake Merrit, Alameda County, September 10, 1906 (Chas. Fuchs); male, Mt. Home, San Bernardino County, July 16, 1921 (F. R. Cole); female, Redlands, April 30, 1924 [all Cole Collection]; five (2♂, 3♀), Meadow Valley, Plumas County, alt., 3,500-4,000 ft., June 8-10, 1924 (E. C. Van Dyke); male, Oakland, Alameda County, August 1905 (E. C. Van Dyke); female Benecia, May 28, 1931 (E. P. Van Duzee); male, Fallen Leaf Lake, El Dorado County, August 1931 (O. H. Swezey); male, Idlewild, July 3, 1928 (E. C. Van Dyke); male, Mill Valley, Marin County, July 6, 1924 (E. P. Van Duzee); female, Fallen Leaf Lake, Lake Tahoe, July 24, 1915 (E. C. Van Dyke) [all, Calif. Acad. Sci.]; male, Mono Lake, July 31, 1940 (R. H. Beamer); female, Mammoth Lakes, July 29, 1940 (L. J. Lipovsky) [Kans. Univ.]; male, Yosemite, June 14, 1931; male, Oakland, May 30, 1937 (E. S. Ross); female, Weott, Humboldt County, July 12, 1929; female, Putah Canyon, Yolo County, March 1934; female, Mono County, 9,350 ft., July 18, 1934 [all, G. E. Bohart Collection]. IDAHO: Five (4♂, 1♀, including one pair captured in *coitu*), Bentwood Lodge, Bear Lake County, July 17, 1921 (B. C. Cain) [F. R. Cole Collection]. These are the specimens cited by Cole (1923, p. 47) as probably *albicinctus*, though atypical. MEXICO: Female, Head of Rio Piedras Verdes, Sierra Madre, Chihuahua, alt. 7,300 ft., July 15 (Townsend), cited by Cole (1919, p. 62) under *O. melampus* [USNM]. NEW MEXICO: Male, Ruidoso, June 26, 1940 (R. H. Beamer) [Kans. Univ.]; female, Rociada, August 8 (Cockerell) [USNM]; female, Mesilla Dam, April 25, 1924 [G. E. Bohart Collection]. OREGON: Six females, Rest Lake, near Summer Lake, Lake County, July 23, 1944 (D. C. Mote) [Oreg. State Col. Collection]; 11 (10♂, 1♀), Stinking Water Mt., Harney County, July 17, 1946 (C. H. Martin); male, female, Corvallis, May 19 and June 3, 1931 (J. Wilcox and C. H. Martin) [C. H. Martin Collection]. The Harney County series contains the darkest specimens that have been seen. WASHINGTON: Female, Waldron Island, July 1, 1909 (W. Mann) [USNM].

OGCODES RUFOABDOMINALIS Cole

Ogcodes rufoabdominalis Cole, 1919, Amer. Ent. Soc. Trans. 45:68, fig. 43. (Utah.)

Ogcodes dusmeti Arias, 1920, Soc. España Hist. Nat. Bol. 20: 191, figs. 1-2. (Mexico.) New synonym?

The study of long series from Goshen and Spanish Fork, Utah, has permitted the proper evaluation of this species and of the variation to be expected. The most dependable characteristics are the following:

Thorax entirely black, sometimes the pleura pale beneath the wing base. Knob of the halteres black. Abdominal dorsum, well illustrated in figure 43 of Cole's monograph (1919), typically orange yellow with a median row of broadly based, subtriangular black spots and on each side a row of small black spots that surround the spiracles. Venter of the abdomen predominantly orange yellow, each sternite with narrow white posterior margin, and narrowly black anteriorly. Basal sternite chiefly to entirely yellow. Legs with a typical consistent color pattern that in itself will distinguish the species from many other *Ogcodes:* Coxae, trochanters, and the extreme bases of the femora narrowly black, the tarsi except for a basal portion of the first segment or two brownish black to black, and claws and pulvilli black; otherwise the femora and tibiae are entirely deep yellow to orange, matching the abdomen. Wings browned, the veins dark, vein M_1 present and rather completely developed, attached basally to the stub of r-m cross vein. Male genitalia entirely black, and virtually the same as those of *O. dispar* and *O. pallidipennis* (cf. figs. 11, 14, 17), with large and well-developed ejaculatory apodeme and the same type of aedeagus. Length 4-5.5 mm.

No specimens of this species were known to me at the time of my previous paper on the genus. With vein M_1 found to be present, the species is, of course, quite unrelated to *albiventris*.

Some variation exists in the extent of the median spots on the dorsum of the abdomen. The pattern figured by Cole is more distinct in the males, ranging from rather small triangles on segments 2 and 3 and broader ones on 4 to 6, to specimens in which the subtriangular spots on the fifth and sixth tergites become so extensive as to connect with the lateral areas to form continuous basal black fasciae. Cole's figure represents an average appearance. The color pattern of the females is not as sharply defined, partly because the abdomen is often collapsed, as usual in this sex. In some female specimens, the abdomen appears entirely brownish to orange without definite median spots, but still quite bright in color compared with the lateral black areas surrounding the spiracles. In general, however, traces of the median black spots can usually be ascertained. The bright orange color of the abdomen contrasts rather strongly with the black thorax, and this will serve to separate the species at once from *pallidipennis* and the other species of *Ogcodes*.

Ogcodes rufoabdominalis is very close to *O. varius* Latreille of Europe. A male of the latter, from Hungary [Cole Collection] has virtually the same color pattern on the abdomen, both dorsum and venter, and has the same

wing venation. However, the genitalia are yellow in part, the humeri, postalar calli, and the scutellum except basally are deep yellow, and the femora are more extensively infuscated. These color differences may not be entirely reliable, but when considered in conjunction with the restricted range of *rufoabdominalis* (as far as known), they appear to warrant the latter's recognition as a distinct species, at least until proved otherwise.

Aside from the two long series from Goshen and Spanish Fork, Utah, only a few other specimens have been seen in collections, and all from Utah with a lone exception. Further collecting will probably demonstrate a somewhat wider distribution.

The description of *Ogcodes dusmeti* Arias is rather lengthy, but I can find nothing to separate the species from *rufoabdominalis,* in view of my observations on color variation in the latter, and the frequently darker color of the females. It may of course be distinct on some other grounds, but I tentatively place it as a synonym of *rufoabdominalis. O. dusmeti* was described from a male and a female, labeled only "Mexico, leg. Conradt, 1903," the types being deposited in the Museo Nacional de Ciencias Naturales, in Madrid, Spain.

Material examined.—Fifty-three specimens. CALIFORNIA: Female, Mammoth Lakes, July 29, 1940 (L. J. Lipovsky) [Kans. Univ.]. UTAH: Twenty-one (12♂, 9♀), Goshen, August 16, 1940 (R. H. Beamer, *et al.*); 26 (23♂, 3♀), Spanish Fork, August 15, 1940 (R. H. Beamer) [Kans. Univ.]; two (♂, ♀), Saltair, May 21, 1926 (M. C. Van Duzee) [Calif. Acad. Sci.]; male, mouth of Bear River, June 17, 1915 (A. K. Fisher) [Cole Collection]; two females, Locomotive Springs, August 17, 1934 (J. A. Rowe) and August 10, 1934 (F. H. Gunnell) [AMNH].

Ogcodes vittisternum, new species

Figs. 2, 3

Male.—Head and thorax black, the antennae and front somewhat testaceous. Abdomen predominantly brown black, with yellow markings (figs. 2 and 3), the pattern of the venter being unique in the genus. The thorax and the median portion of the abdominal dorsum with long, erect, yellow to brownish-yellow hair, the longest on the abdomen subequal in length to the hind metatarsus.

Legs yellow, the coxae, trochanters, and claws black, a basal portion of all femora infuscated (apparently about three-fourths, although the condition of the legs does not permit a definite statement, and the proportion is probably variable anyway); legs moderately slender, the tibiae only slightly enlarged and the greatest tibial diameter only slightly greater than the metatarsal diameter.

Wings hyaline, veins yellow, r-m cross vein absent, vein M_1 present in full length but pale and weak. Squamae slightly browned with dark brown to black margins. Halteres brown.

Genitalia black, unusually small in proportion to the size of the abdomen; ejaculatory apodeme small and inconspicuous; "wing spread" subequal to the

greatest width of the aedeagus, and three-fourths the length of the apodeme in end view; median plate short, narrow in side view, and relatively thick, the thickness (end view) 0.3 times the length of the apodeme; distal end of the aedeagus broken.

Length, 5 mm.

Holotype, male, Homestead Inn, Mount Hood, Oreg., July 6, 1927 (E. C. Van Dyke). Type in the F. R. Cole Collection.

The pattern of the venter of the abdomen will separate the species from any others known to the writer in North America. It is also one of the species having long hair, especially on the dorsum of the abdomen.

Ogcodes floridensis, new species

Figs. 4, 19

Male.—Head black, the antennae yellowish. Thorax shining black, densely clothed with long, pale, appressed hair, the anterior corners of the mesonotum, posterolaterad of the humeri, the mesopleura, and the anterior half of the pteropleura, reddish yellow; scutellum slightly reddish apically.

Dorsum of the abdomen predominantly bright yellow with brown markings (fig. 4): Second tergite entirely yellow, the third and fourth each with three brown spots, one median and one on each side immediately above the spiracle, those on the fourth segment somewhat larger; fifth and sixth tergites almost entirely shining brown; all tergites with erect, whitish hair, longer than usual in species of this genus though not as long as in the other species of the *colei* complex. Venter of the abdomen also predominantly bright yellow, the sides of the sternites brown and probably a narrow anterior fascia brown, although the latter cannot be seen in the type because of slight telescoping of the segments; first sternite yellow, with only a narrow, elongate spot across the middle of the sternite; second sternite almost entirely yellow, the lateral spots quite faint.

Legs yellowish, the coxae, trochanters, and basal two-thirds of all femora dark brown; tarsi somewhat darkened distally, except the last segment; pulvilli brown and claws black.

Wings hyaline, veins brown, vein M_1 present but only faintly indicated, not as strong as in *pallidipennis,* and in certain lights even appearing to be absent; r-m cross vein absent. Squamae yellowish with dark margins. Knob of the halteres black, the stalk yellow.

Genitalia similar to *vittisternum,* relatively small and with small and inconspicuous ejaculatory apodeme; "wing spread" subequal to the greatest width of the aedeagus; aedeagus with the dark basal portion relatively broad, suddenly narrowed at the distal third; distal end of the aedeagus in side view (fig. 19) with apical fingerlike process.

Length, 5 mm.

Holotype, male, Brevard County, Fla., November 22, 1929 (Julian Howard). Type No. 58365 in the United States National Museum.

The wing venation is somewhat intermediate between the two types described in the first couplet of the key. Vein M_1 is present but very rudimentary throughout its length. Because it is pale and weak, whereas the veins on either side are brown and stand out more definitely, the vein might easily be misinterpreted as being absent; only a careful examination will show that the membrane is not blank, but that traces of the vein are present. Fortunately, the dorsum of the abdomen is so distinctly patterned that the species will not be confused with any of the others.

The thorax of the type is not in good condition. There is a suggestion of a pattern similar to that of *Acrocera subfasciata* (cf. Sabrosky, 1944, fig. 8), and it is possible that well-preserved specimens will show a distinctly marked thorax.

Ogcodes shewelli, new species
Figs. 6, 20

Male.—Head black, the front and antennae yellow. Thorax entirely black, only the lower fourth of the mesopleura yellow. Abdomen predominantly bright yellow, with brownish-black markings (fig. 6); the dorsum conspicuously patterned with a median row of large brown triangular spots on the second to fourth tergites, the venter entirely pale yellow except for faint infuscation on the first sternite. Both thorax and the disk of the abdomen thickly beset with long, erect, whitish-yellow hair, that of the abdomen nearly as long as the hind metatarsus. Genitalia yellow.

Legs predominantly bright yellow, only the coxae, trochanters, and claws black; all quite slender, the tibiae not stout and not strongly enlarged apically as in many other species of the genus.

Wings hyaline, veins pale yellow, r-m cross vein absent, vein M_1 present in full length but pale and weak. Squamae whitish with yellow margins. Halteres brown.

Genitalia like *vittisternum* and *floridensis,* relatively small with small and inconspicuous ejaculatory apodeme; "wing spread" subequal to the greatest width of the aedeagus, and equal to or a trifle greater than the length of the apodeme in end view; median plate short and thick, apparently much like that described for *vittisternum;* distal end of the aedeagus in side view with abruptly curved fingerlike process (fig. 20).

Length, 5 mm.

Holotype, male, Niagara Glen, Ontario, July 27, 1925 (G. S. Walley). Type in the Canadian National Collection at Ottawa.

The species is named for Mr. G. E. Shewell, of the Canadian Department of Agriculture, who first recognized that the specimen belonged to an undescribed form and kindly loaned it to the writer for description.

Ogcodes shewelli is closely related to *O. floridensis* by such characters as the long, whitish hair, the slender legs, and the predominantly yellow abdomen.

Ogcodes colei, new species
Figs. 7, 18

Male.—Very close to *O. vittisternum,* differing from that species by a slightly different color pattern on the dorsum of the abdomen (fig. 7), the second and third tergites broadly yellow on the sides; venter of the abdomen predominantly yellow, the first and sixth sternites shining brown, the intervening sternites with a row of small brown spots on each side, as in *vittisternum,* but no median row of spots; the long hairs on the abdomen slightly greater in length than the hind metatarsus; otherwise as described for *vittisternum.*

Genitalia similar to the preceding three species, relatively small with small and inconspicuous ejaculatory apodeme; "wing spread" about three-fourths the width of the aedeagus and two-thirds the length of the apodeme in end view; apodeme in end view of peculiar shape, the median plate rather thick (as in *vittisternum*) with lateral projections at the end opposite the "wings," the whole having the appearance of a thick Roman numeral I; in side view the median plate is narrow, its width barely over one-third the length; distal end of the aedeagus in side view with slender fingerlike process (fig. 18).

Length, 5-6 mm.

Holotype, male, Huachuca Mts., Ariz. Type No. 58366 in the United States National Museum. Paratype, male, Tallao Lake, Tahoe, Calif., July 5, 1915 (E. P. Van Duzee) [F. R. Cole Collection].

The paratype differs slightly from the type in having a greater amount of yellow on the fourth and fifth tergites, though the same fundamental pattern on the other tergites and on the venter stamps it as the same species. Further, the abdominal hairs are particularly long and outstanding in the paratype, and basal three-fourths of all the femora are dark brown.

One other male, from Clear Lake, Lake County, Calif., July 28, 1934 (E. C. Van Dyke) [Calif. Acad. Sci.], probably belongs here, but the specimen is in too poor condition to be sure.

A female from Grass Valley, Calif., May 18, 1930 (E. P. Van Duzee) [Calif. Acad. Sci.] may possibly be the female of this species. The yellow venter and long hair are suggestive of *O. colei,* but the dorsum is dark brown.

The species is named in honor of Frank R. Cole, whose monograph in 1919 presented a series of excellent plates that are invaluable aid in studying the American species of this relatively uncommon family.

OGCODES ALBIVENTRIS (Johnson)
Figs. 8, 9

This species is known only from two males from widely separated localities: the type from Toronto, Ontario, and a specimen from Livermore, Calif. (recorded by Cole, 1923, p. 47). The species was correctly placed in my 1944 revision, based on notes on the type that were kindly furnished me by Mr. Nathan Banks. I have now seen both specimens, and was able to compare the California specimen directly with the type. It is slightly darker than the type,

and the short fasciae on the abdomen are stronger; otherwise the two are practically identical. The distinctive color pattern, both dorsal and ventral, separates them at once from all other species.

The salient features of the species are as follows: The entire thorax, knob of the halteres, coxae, trochanters, the basal fourth to third of the femora, apical portion of last tarsal segment, and claws, black; abdomen white to whitish yellow with black markings as figured (figs. 8 and 9, from the California specimen, loaned by Dr. Cole); the thorax and a broad median portion of the dorsum of the abdomen with unusually long, erect, whitish to yellowish hair, that on the abdomen as long as the hind metatarsus; venter with short fine hair except on the second sternite, whose pile is nearly though not quite as long as on the dorsum; wing venation of the reduced type with vein M_1 entirely absent.

Unfortunately, the male genitalia were broken in the available specimen (California), and neither the ejaculatory apodeme nor the distal end of the aedeagus could be studied. The other characteristics of the species indicate some affinities with both the *eugonatus* complex and with the new species of the *colei* complex, and it will be interesting to see what type of ejaculatory apodeme it proves to have.

OGCODES MELAMPUS (Loew)

The type series of two males and one female from California, in the Museum of Comparative Zoology, was examined recently. The species belongs to the group with vein M_1 absent, and is closely related to *eugonatus*. In my previous paper, I had erroneously believed that *melampus* belonged to the other group, with M_1 present. *Melampus* in the sense of both Cole (1919) and Sabrosky (1944) is discussed elsewhere in this paper as a dark western form, and possibly a subspecies, of *pallidipennis*.

The legs are entirely black (or appear so, since at most the knees are only narrowly yellow, and the tibiae sometimes dark reddish ventrally), and the specimens thus have a much darker habitus than typical *eugonatus*. In addition to the dark legs, the males are distinguished from those of *albicinctus* by narrower yellow fasciae on the abdominal tergites, their width usually about one-third the length of a tergite, though in two specimens the yellow fascia of the fifth tergite is nearly one-half the length of the segment. In spite of the apparent differences, however, I am inclined to suspect that adequate material for dissection would show only two species of this complex, *eugonatus* and a second species that I recognize here as *albicinctus*. If true, the specimens that have been identified as *melampus* would be melanic individuals of the one or the other. Whether the name *melampus* would then fall as a synonym of *eugonatus* or would supplant *albicinctus* can only be determined by dissection of Loew's male cotypes. If the broad yellow fasciae of *albicinctus* are really a specific criterion, it would seem reasonable to suspect that specimens of *melampus* will bear the same relationship to the eastern *eugonatus* that the dark western forms of *pallidipennis* bear to the typical eastern form.

Several of the males cited below were dissected, and the male genitalia were approximately the same as figured and described for *eugonatus*. The chief difference, and that not strongly evident, was a somewhat narrower "wing spread," about one and one-half times (1.43-1.56) the greatest breadth of the aedeagus and thus slightly shorter in proportion to the length of the apodeme (0.56-0.62). The appearance of the distal end of the aedeagus varied, some resembling typical *eugonatus* and some being intermediate between that species and *albicinctus*. In general, the specimens seemed closer to *eugonatus*.

The females that I associate with male *melampus* have the same black legs; otherwise they are like the females of *eugonatus* and *albicinctus*.

The specimens known to me are all from the far western states and Alaska. The species may be close to *O. nigripes* Zetterstedt of northern Europe, also characterized by entirely black thorax and legs.

Material examined.—Nine specimens. ALASKA: Male, long. 141°, lat. 69°-69.20°. July 12-20, 1912 (J. M. Jessup) [USNM]. CALIFORNIA: Male, Alviso, June 5, 1922 (E. O. Essig) [Cole Collection]; female, Santa Cruz Mts. [USNM]; female, Carrville, Trinity County, alt. 2,400-2,500 ft., May 29, 1934, "under yellow pine bark" (B. J. Hall) [Calif. Acad. Sci.]. NEVADA: Male, Ormsby County, July 6 (C. F. Baker) [USNM]. WASHINGTON: Three (2♂, 1♀), Mount Rainier, Shadow Lake, 6,200 ft., August 15, 1932 [USNM and C. H. Martin Collection]; male, Mount Rainier, Paradise Valley, 6-8000 ft., August 7, 1919 (C. L. Fox) [Calif. Acad. Sci.].

OGCODES ALBICINCTUS Cole

Fig. 22

(= *marginatus* Cole, preoccupied)

This northwestern species was distinguished in the male sex from the related *eugonatus* in my previous key to *Ogcodes* (Sabrosky, 1944, p. 389). Figure 42 of Cole (1919) clearly shows the characteristically broad white fasciae on the abdomen.

The series of specimens now before me indicates that this is a reasonably reliable criterion, even though subject to some variation in the width of the fasciae. With more examples available, it is also now apparent that the color of the legs varies somewhat, darker specimens approaching the pattern found to be characteristic for *eugonatus*. Nor do all specimens show the faint distal portion of vein M_1 as found in the type. In spite of these variations, however, the breadth of the abdominal fasciae remains an outstanding feature that will separate the males of *albicinctus* from either the eastern *eugonatus* or the western *melampus*.

Male genitalia virtually the same as described and figured for *O. eugonatus* (q. v.), the proportions only slightly different; ejaculatory apodeme in end view approximately as figured for *eugonatus* (fig. 12), but the subbasal triangle narrower and the flattened apical portion of the median plate proportionately longer, nearly one-half the length of the apodeme; in side view the profile of the median plate slightly different in shape from that of *eugonatus;* distal end of the aedeagus more slender than in *eugonatus,* and of somewhat different appearance in profile (fig. 22).

Unfortunately, no reliable criterion could be found for distinguishing females of *albicinctus* and *eugonatus*. Except where collected in association with identifiable males, they can only be determined as probably the one or the other on the basis of the different distribution of the two species, as far as known.

A few specimens from Manhattan, Kans., and from Texas have been seen which seem to be intermediate between *eugonatus* and *albicinctus* in the width of the abdominal fasciae. Very little material is available from the Great Plains area, and it is impossible to say whether we have here intergradation between eastern and western subspecies, or extreme variation of the one or the other species. Those specimens are not now available for dissection of the male genitalia.

Material examined.—Twenty-one specimens. ALBERTA: Male, Cooking Lake, July 25, 1937 (F. O. Morrison); three (♂, 2♀), Wabamun, July 13, 1939 (E. H. Strickland); female, Edmonton, July 13, 1936 (E. H. Strickland) [all, F. R. Cole Collection]. CALIFORNIA: Eight (♂, 7♀), Talbert, Orange County, June 4, 1927 (A. C. Davis); female, Santa Clara County (Harkins) [Cole Collection]; male, Los Angeles County, September (Coquillett) [USNM]; female, Orange Grove, San Diego County, May 26, 1936 (C. F. Harbison) [San Diego Mus. Nat. Hist.]; male, San Jacinto, May 29, 1917 (E. P. Van Duzee) [Calif. Acad. Sci]. MONTANA: Male, Lake View, August 4, 1920 (A. N. Caudell); two males, Centennial Valley, Bozeman (G. Allen Mail) [USNM]. UTAH: Male, Salt Lake, June 26 (H. S. Barber) [USNM].

OGCODES EUGONATUS (Loew)
Figs. 12, 15, 21

The status of this species was fully discussed in my 1944 review of the genus, and the considerable amount of material studied since that time has borne out the conclusions then reached.

Male genitalia with large, well-developed ejaculatory apodeme; "wing spread" 1.7 times the greatest breadth of the aedeagus but little over three-fifths (0.64-0.67) times the length of the apodeme in end view because of the long median plate (fig. 12); median plate large, in side view two to three times as long as wide (fig. 15), broadly expanded basally but the subbasal cell narrowly triangular in end view (fig. 12); distal end of the aedeagus in side view as figured (fig. 21).

Distribution.—Like *pallidipennis,* this species is widespread and relatively common in eastern United States. A large number of records are available, but need not be given in detail. Since the previous paper (1944) over 80 specimens have been seen (37♂, 40♀, plus several not recorded as to sex) from the following states and provinces: Arkansas, Colorado, District of Columbia, Illinois, Kansas, Maine, Massachusetts, Missouri, New York, Ohio, Oklahoma, Ontario, Texas, Virginia, West Virginia, and from Mexico.

The following records are of especial interest: Female, Coulterville, Ill., June 18, 1911, "bred from fresh cell of *Sceliphron cementarius*" (A. A. Girault [USNM, recorded by Cole, 1919, as *O. pallidipennis*]; 43 (18♂ 25♀), Cherokee County, Kans., September 2, 1940 (R. H. Beamer) [Kans.

Univ.]; male, Sproule Bay, Lake Opeongo, Algonquin Park, Ontario, June 26-July 7, 1945, "emerged from abdomen of spider *Pardosa distincta* (Blackwall)" (W. Ivie and T. B. Kurata) [AMNH]; female, Cuautla, Morelos, Mexico, October 28, 1922 (E. G. Smyth) [USNM].

Seasonal distribution of the above material: April 12 (Calvert, Tex.), May 4 (Stillwater, Okla.) to September 6 (Kansas) in the United States. The latest recorded specimen was collected on October 28 at Cuautla, Mexico. Many more specimens of this species were collected in August and September than was true for *pallidipennis*.

OGCODES HUMERALIS (Osten Sacken)

Oncodes humeralis Osten Sacken, 1887, Biol. Centr.-Amer., v. 1, p. 164. (N. Sonora, Mexico.)

This species cannot be recognized from the description. About all that can be said is that the words "venter whitish-yellow" eliminate *borealis* as a possibility, and the statement "abdomen brown, the hind margins of the segments white" eliminates such species as *rufoabdominalis*, *albiventris*, and others in which the males have a distinctive color pattern. Other than these, *humeralis* might be any of several species, and the status of the name must await study of the type. If the sex has been misinterpreted and the type proves to be a female, it may be impossible to associate it definitely.

OGCODES AEDON (Townsend)

Oncodes aedon Townsend, 1895, Calif. Acad. Sci. Proc., ser. 2, No. 4:607. (Lower California.)

The remarks under *O. humeralis* apply equally well here. The type, originally deposited in the California Academy of Science, was destroyed in 1906. Dr. Aldrich saw the type in 1905, but his notes are brief and do not serve to identify the species. The male identified as *aedon* by Cole (1919, p. 65), from Los Angeles County, Calif. (Coquillett) [USNM], belongs in the *pallidipennis* complex (cf. discussion under its western specimens).

OGCODES NIGER Cole

Ogcodes niger Cole, 1919, Amer. Ent. Soc. Trans. 45:65. (Utah.)

The female holotype has been studied [MCZ], but because no reliable characters have yet been discovered for the separation of most of the females in this genus, the name cannot be applied with certainty to any of the species before me. It must therefore be left as unrecognizable.

OGCODES sp.

On female specimen, Kaslo, British Columbia, June 24 (R. P. Currie) [USNM], is either an undescribed species or a teneral *O. dispar*. The thorax, abdomen and legs are entirely orange yellow, but it is in poor and collapsed

condition, and the color of a fully matured specimen might be otherwise. Vein M_1 is present in the wing. It is very far from the recorded range of *dispar*, but the intervening region is relatively little known with respect to the occurrence of this family. No other specimen resembling it has been seen in the western material that I have examined, and it seems best to leave it unnamed until further specimens make it possible to determine its status.

REFERENCES*

COLE, F. R. 1919—The dipterous family Cyrtidae in North America. Amer. Ent. Soc. Trans. 45: 1-79, 15 pls.

———1923—Notes on the dipterous family Cyrtidae. Psyche 30: 46-48.

JOHNSON, C. W. 1904—Some notes, and descriptions of four new Diptera. Psyche 11: 15-20.

———1915—Note on the species of the genus *Acrocera*. Psyche 22: 198-203.

SABROSKY, CURTIS W. 1943—A new species of and notes on Acroceridae. Ent. News 54: 176-182.

———1944—A revision of the American spider parasites of the genera *Ogcodes* and *Acrocera*. Amer. Midl. Nat. 31(2): 385-413, 1 pl.

* References used repeatedly in the paper. Lone citations are given where they occur.

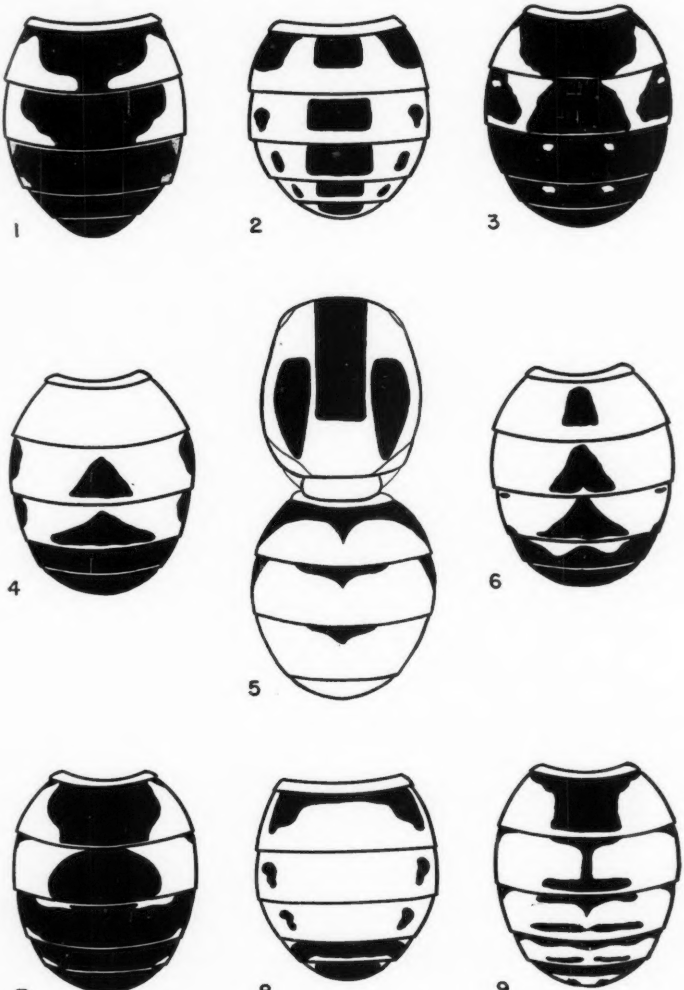


Plate I, figs. 1-9. Diagrammatic color patterns of male acrocerid flies. Figs. 2 and 8 show the ventral aspect of the abdomen; all others show the dorsal aspect.

Fig. 1, *Ocnaea sequoia* (holotype); 2 and 3, *Ogcodes vittisternum;* 4, *O. floridensis;* 5, *Acrocera stansburyi* (paratype); 6, *Ogcodes shewelli;* 7, *O. colei* (holotype); 8 and 9, *O. albiventris* (Livermore, Calif.).

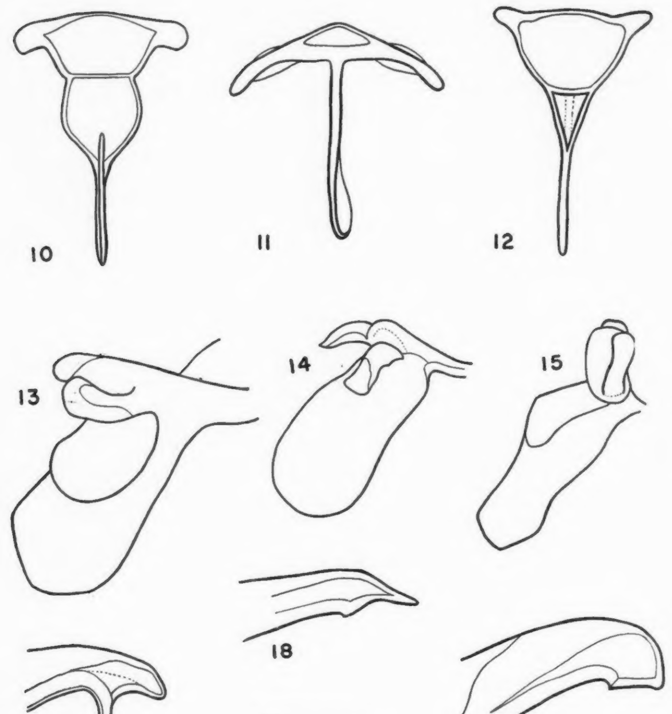


Plate II, figs. 10-22. Male genitalia of *Ogcodes* species. Figs. 10-12 show the anterior aspect or end view, and figs. 13-15 the side view, of the ejaculatory apodeme; figs. 16-22 show the distal end of the aedeagus, in side view.

Figs. 10, 13, and 16, *O. borealis* (Waterton, Alta.); figs. 11, 14, and 17, *O. pallidipennis* (Shasta Co., Calif.); figs. 12, 15, and 21, *O. eugonatus* (Beulah, Mich.); 18, *O. colei* (Holotype); 19, *O. floridensis;* 20, *O. shewelli;* 22, *O. albicinctus* (Centennial Valley, Mont.).

Dendrouterina botauri n. sp., A Cestode Parasitic in Bitterns, With Remarks on Other Members of the Genus*

Robert Rausch
Department of Veterinary Science, University of Wisconsin, Madison

A single cestode belonging to the genus *Dendrouterina* Fuhrmann, 1912, was taken from the small intestine of a least bittern, *Ixobrychus e. exilis* (Gmelin), collected by the writer on May 31, 1945, at Buckeye Lake, Ohio. Considerable difficulty was experienced in obtaining adequate material of this cestode, although bitterns were collected in Ohio, Michigan, Wisconsin, and Manitoba. A second infected bird, an American bittern, *Botaurus l. lentiginosus* (Monatgu), was collected on April 24, 1947, at Horicon Marsh, Wisconsin. Three specimens of *Dendrouterina* were obtained from this bird.

Unfortunately, since refrigeration was not available in the field, the scolices of all four specimens had degenerated by the time the autopsies were made. However, since this species is so obviously different from those previously described, the description is presented with this inadequacy.

Whole-mounts, stained with Semichon's acetic carmine, were made, and all observations were substantiated by observations on frontal and transverse serial sections, cut at 15 μ, and stained with haematoxylin-eosin.

Dendrouterina botauri n. sp.

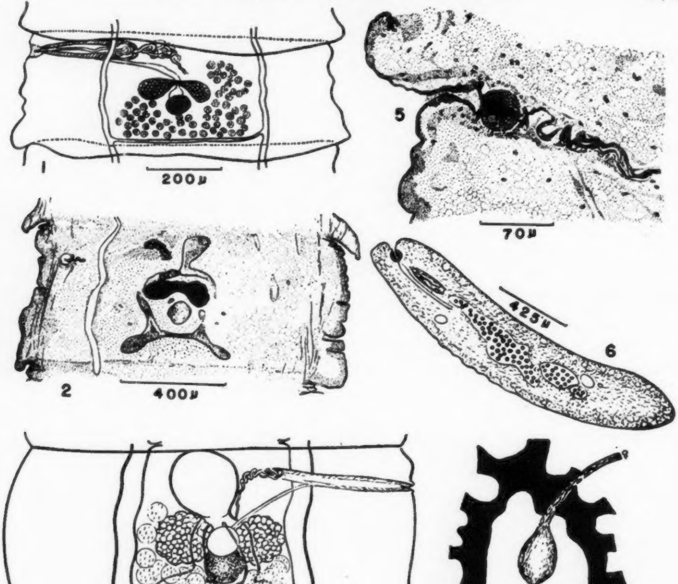
Diagnosis.—Strobila about 150 mm long; maximum width, attained in gravid proglottids, about 2 mm. Strobila consists of about 140 proglottids. Margins of mature proglottids serrate, while margins of gravid proglottids are convex. Longitudinal muscle fibers numerous, arranged several deep in apparently a single layer. Transverse muscle fibers not seen. Scolex unknown.

Ventral excretory canals about 30 to 50 μ in diameter; their course somewhat undulating. Aporal ventral excretory canal situated dorsally, while poral canal is in usual ventral position. Transverse canals about 20 μ in diameter in central area of segment, and narrower near junction with longitudinal canals. Transverse canals situated just behind testes near posterior border of the proglottid; accessory canals, which transverse the proglottids in an irregular manner, may be present. The dorsal canals are about 2 μ in diameter in mature proglottids.

Genital ducts dorsal to longitudinal excretory vessels. Genital pores unilateral and dextral, situated near the anterior margin of the proglottid. Genital atrium deep; not lined with chitinous spines.

---

* This work supported in part by the Research Committee of the Graduate School from funds supplied by the Wisconsin Alumni Research Foundation.



Figs. 1-8. *Dendrouterina botauri* n. sp.—1. Typical mature proglottid, from *Botaurus* (ventral view). 2. Frontal section of an early post-mature proglottid from *Botaurus* (ventral view). 3. Later post-mature proglottid, from *Ixobrychus* (dorsal view). 4. Gravid proglottid, from *Ixobrychus* (dorsal view). 5. Frontal section showing details of terminal part of vagina, from *Botaurus*. 6. Cross section showing position of ventral excretory canals from *Ixobrychus*. 7. Central area of gravid proglottid showing seminal receptacle and vitelline gland, from *Ixobrychus*. 8. Frontal section showing details of male reproductive organs, from *Botaurus*.

Cirrus sac dorsal and somewhat anterior to vagina; it measures from 254 to 380 μ in mature proglottids. Cirrus sac thick-walled, and may extend beyond ventral excretory canal nearly to mid-line in mature proglottids. Cirrus spined, and somewhat coiled within cirrus sac. There appears to be a very small internal seminal vesicle, but this was not always visible in sectioned material. External seminal vesicle absent. Vas deferens forms numerous coils medial to end of cirrus sac. Testes are ovoid, from 45 to 56 in number (average 49), and are situated posterior, lateral, and mostly dorsal to female reproductive organs. Testes measure from 23 to 36 μ long by 20 to 26 μ wide (average 31 by 22 μ) in mature proglottids. Testes enlarge in post-mature proglottids, before disappearing. On aporal side of proglottid, testes extend forward to level of genital pore; on poral side to level of anterior margin of the ovary. Testes lie mainly in same plane, not more than two deep, and concentrated more in the lateral fields. They do not extend laterally beyond the longitudinal excretory canals. Testes are connected by a network of vasa efferentia, which usually arise from the antero-dorsal surface of the organs.

Vagina is ventral and slightly posterior to cirrus sac; it is provided with a large sphincter, about 50 μ in diameter, at the genital atrium. Vagina runs medially toward the ovary, with few undulations, to join large seminal receptacle between ovary and vitelline gland, and ventral to the latter. The ovary consists of two ovoid lobes connected by a narrow band; the lobes become spherical and enlarged in the post-mature proglottids. Vitelline gland is large and spherical; situated immediately posterior to ovary on the mid-line.

Uterus is first visible as an ovoid to spherical sac anterior to the ovary, and gradually extending to anterior margin of the proglottid. The early uterus completely surrounds the ovary and vitelline gland, ventral to them. Three enlargements are seen in the early uterus; one anterior to the ovary, and two posterior. The post-mature proglottids, along with the uterus, elongate rapidly, and lateral branches appear on the latter. The hollow center of the uterus is retained, and, as the proglottids become older, the side branches elongate and subdivide. The poral edge of the gravid uterus is dorsal to the ventral excretory canal, while the aporal edge is ventral to the aporal ventral canal. The vitelline gland and seminal receptacle, along with the vagina and cirrus-sac, are retained in the fully gravid proglottids. Shape of gravid uterus is somewhat variable. Eggs are not densely packed.

The embryos measure 25 μ in diameter, with hooks about 8.4 μ in length. Outside diameter of egg about 33 μ. Shell unusually delicate and often not visible.

Host.—*Botaurus l. lentiginosus* (Montagu) (American bittern), and *Ixobrychus e. exilis* (Gmelin) (least bittern).

Habitat.—Small intestine.

Locality.—Buckeye Lake, Ohio (*Ixobrychus*), and Horicon Marsh, Wisconsin (*Botaurus*).

Type.—A total preparation from *Botaurus* has been deposited in the Helminthological Collection of the U. S. National Museum.

DISCUSSION

The genus *Dendrouterina* was erected by Fuhrmann (1912) for a cestode, *D. herodiae* Fuhrmann, 1912, from an egret, *Garzetta garzetta* (Lin.) as type. *Dendrouterina botauri* differs from *D. herodiae* in the formation and shape of the gravid uterus. In *D. herodiae* the gravid uterus is "hufeisenförmig," and not closed posteriorly. In *D. botauri* the uterus is completely closed posteriorly; it surrounds the female reproductive organs in the early mature proglottid (fig. 2), and encloses the seminal receptacle and vitelline gland in fully gravid proglottids (figs. 4 and 7).

Especially characteristic of *D. botauri* is the formation of the uterus, which, when first observed in post-mature proglottids, entirely surrounds the ovary and vitelline gland, with a single anterior enlargement, and two posterior ones (figs. 2 and 3). As seen in Fuhrmann's (1912) figure 5, the uterus in *D. herodiae* is net-like in its early stages of formation, while this is not true of that of *D. botauri.*

Dendrouterina botauri is larger than *D. herodiae,* and apparently has a greater number of testes. If each species is found to possess an armed rostellum, it is possible that there will be differences in the number and size of the hooks. According to Dr. J. G. Baer (personal communication) the genital atrium of *D. herodiae* "is very peculiar in that it is muscular and lined with long, thin, chitinous spines." The genital atrium of *D. botauri* is not lined with such spines, as disclosed by the examination of serial sections under oil immersion.

Three other species have been assigned to the genus *Dendrouterina,* but, for reasons pointed out below, their inclusion in this genus is not acceptable.

The diagnosis of the genus *Dendrouterina* was given by Fuhrmann (1912) as follows: "Skolex unbekannt. Die Geschlechtsgänge gehen zwischen den Wassergefässen durch zur Genitalkloake, die Genitalöffnungen sind einseitig; die zahlreichen Hoden hinter den weiblichen Geschlechtsdrüsen; Uterus hufeisenförmig mit besonders zahlreichen seitlichen Verzweigungen, welche auf der poralen Seite *über,* auf der antiporalen Seite *unter* dem weiten Längsgefäss durch ins Rindenparenchym dringen. Das Wassergefässsystem zeigt auf der antiporalen Seite das enge, sonst dorsale Längsgefäss ventral von weiten Exkretionsstamm."

It is evident from this that a highly-branched uterus and a dorsally-placed aporal ventral excretory canal are requisite characters of the genus.

According to Dr. J. G. Baer (personal communication), who has just examined Fuhrmann's original material, the genital ducts are *dorsal* to the longitudinal excretory canals in *D. herodiae,* and do not pass between them, as was originally stated.

Dendrouterina fovea Meggitt, 1933, was the second species to be assigned to the genus. Unfortunately, Meggitt's description is inadequate, so that many

details are not available. It was stated, however, that the uterus is "a branched sac, not extending laterally to the excretory vessels." The gravid uterus was not figured, and no mention was made of the typical arrangement of the ventral excretory canals; a feature which, if present, could hardly have been overlooked. *Dendrouterina fovea* was also parasitic in a passeriform bird, while both *D. herodiae* and *D. botauri* are parasites of ardeiforms.

Dendrouterina nycticoracis Olsen, 1937, and *D. lintoni* Olsen, 1937, were described from ardeiform birds. Through the kindness of Dr. E. W. Price, the writer had the opportunity of examining Olsen's original material. The great size difference is at once apparent; both *D. nycticoracis* and *D. lintoni* being relatively very small. The genital ducts in Olsen's species pass between the excretory canals, instead of dorsal to them, as is the case in the genus *Dendrouterina*. Serial sections of *D. nycticoracis* and *D. lintoni* were unfortunately not available to the writer, but there is no indication that the ventral excretory canals have the arrangement typical for the genus. According to Olsen (1937b), "in *Dendrouterina* the ventral duct on the poral side is large and the dorsal one minute, whereas the opposite condition obtains on the aporal side." Examination of whole mounts and serial sections of *D. botauri* reveals that Fuhrmann's original conclusion is correct in regard to the arrangement of these canals; he stated that "Das Wassergefässsystem zeigt deutlich ein Paar sehr weiter Längsgefässe, welche ein ebenfalls weites, am Hinterrand der Glieder liegendes Quergefäss aufweisen." There can be no error in assuming this arrangement, since, in frontal serial sections of *D. botauri*, the large ventral canals were obviously connected by transverse canals, and the dorsal canals showed only the usual arrangement.

The gravid uteri of *D. lintoni* and *D. nycticoracis* do not resemble in the least that of *D. botauri*, nor, as far as can be determined from Fuhrmann's figure, that of *D. herodiae*. The gravid uteri of the former two species are typical, sac-like, somewhat lobed dilepidid uteri, without the central opening, and without the characteristic branchings. The gravid uterus in *D. botauri* is more comparable in appearance with that found in the genera *Taenia* and *Cladotaenia*. In the opinion of the writer, *D. lintoni* and *D. nycticoracis* belong in the genus *Dilepis* Weinland, 1858.

With only *D. herodiae* and *D. botauri* remaining in the genus, the type of scolex remains unknown. It is hoped that this will prove to be of some value in determining the relationships of *Dendrouterina*. Fuhrmann (1912) stated "Über die Stellung dieses Genus im System ist es schwer sich auszusprechen, da der Skolex leider unbekannt ist. Nach der Muskulatur zu urteilen, gehört das Genus vielleicht den Anoplocephaliden an, ich stelle aber dasselbe vorläufig in die Familie der Dilepiniden." The genus has been retained in the family Dilepididae, but it will probably be placed elsewhere after additional material has been studied.

SUMMARY

1. A new species of cestode, *Dendrouterina boutauri*, is described from North American bitterns.

2. Three other species previously assigned to the genus *Dendrouterina* are discussed, and it is concluded that they belong elsewhere. The description of *D. fovea* Meggitt, 1933, is not adequate to allow its assignment to the proper genus, but *D. lintoni* Olsen, 1937, and *D. nycticoracis* Olsen, 1937, are considered as belonging in the genus *Dilepis* Weinland, 1858.

3. Two species are now known for the genus *Dendrouterina;* they are *D. herodiae* Fuhrmann, 1912, and *D. botauri* n. sp. The scolices are unknown for both.

ACKNOWLEDGMENT

The writer is indebted to Dr. J. G. Baer, Director of the Institut de Zoologie, Université de Neuchâtel, for details resulting from his examination of Fuhrmann's original material, and for very helpful suggestions; to Dr. E. W. Price, Zoological Division, Bureau of Animal Industry, for the loan of Olsen's type material; and to Mr. Wayne Truax, Leader, Pittman-Robertson Muskrat Project, Horicon Marsh, Wisconsin, for aid in obtaining bitterns from that area.

REFERENCES

FUHRMANN, O. 1912—Ergebnisse der mit Subvention aus der Erbschaft Treitl unternommenen zoologischen Forschungsreise Dr. Franz Werner's nach dem ägyptischen Sudan und Nord-Uganda. XXI. Vogelcestoden. Sitzungsb. K. Akad. Wiss. Wien, Math.-Naturw. Klasse 121:181-192.

MEGGITT, F. J. 1933—Cestodes obtained from animals dying in the Calcutta Zoological Gardens during 1931. Rec. Ind. Mus. 35-145-165.

OLSEN, O. W. 1937a—A new species of cestode, *Dendrouterina nycticoracis*, from the black-crowned night heron (*Nycticorax nycticorax hoactli*) (Gmelin). Proc. Hel. Soc. Wash. 4:30-32.

———1937b—A new species of cestode, *Dendrouterina lintoni* (Dilepididae), from the little green heron, (*Butorides virescens*) (Linn.) Ibid. 4:72-75.

Effect of Fire on the Competition Between Blue Grass and Certain Prairie Plants*

John T. Curtis and Max L. Partch
Botany Department, University of Wisconsin, Madison

Introduction

The University of Wisconsin Arboretum in Madison lies in the ecotone region between prairie and hardwood forest formations and only a short distance from the southern border of the boreal forest formation. While the climate does not allow for optimum development of any of these main formations, it does permit the existence of elements of all three plant groups. The prevailing conditions appear to be most favorable for the hardwood forest, since the succession on undisturbed areas generally proceeds towards that climax. In areas with suitable microclimatic or edaphic conditions, association fragments of the other formations persist, such as tall-grass prairie on thin-soil limestone bluffs. Seemingly, prairies may also occur in other places where fire or other agencies prevent the invasion of woody species. It is believed that by the judicious use of fire or other biotic controls, fairly complete examples of the several associations of each of the formations can be established and maintained within the 1400 acre limits of the Arboretum; it is hoped that much information of value concerning the dynamics of formation boundaries can be obtained in the course of such establishment. The present paper reports briefly on one phase of the work, namely the effect of fire on the growth and spread of certain planted prairie species in competition with a dense sod of old field blue grass.

Materials and Methods

A field of Miami silt loam soil was abandoned from cultivation in 1932. Ruderals of various sorts soon occupied the land, with perennial grasses, especially quack grass (*Agropyron repens*), Kentucky blue grass (*Poa pratensis*) and Canada blue grass (*Poa compressa*) in nearly complete control by 1936. A number of prairie forbs and prairie grasses were transplanted into the area in 1936 and 1937, each in a separate plot at a nearly uniform spacing of 2.6 plants per 100 square feet. These prairie species were obtained as mature plants from special nurseries or, in the case of the grasses, as sods from nearby relic prairie stations. It soon became evident that most of the planted species were not spreading, or in some cases, were not holding their own. The most obvious reason for the lack of spread was found upon superficial observation to be the competition afforded by the blue grass sod, which had become

* Contribution from the University of Wisconsin Arboretum. Journal Paper No. 12. This work was supported in part by the Research Committee of the Graduate School from funds supplied by the Wisconsin Alumni Research Foundation.

extensive and well-developed. Accordingly, an experiment was designed to study the effect of fire as an agent for reducing the competitive ability of the blue grass and to determine whether the prairie species would spread under the new conditions.

Narrow plots, 25 ft. x 220 ft., were laid out through the region of planted species and into the control area beyond. Because the original planted areas were not exactly uniform in shape, it was impossible to include all of the species in all of the experimental plots. Therefore, the data in some of the tables are incomplete. During the period from 1941 through 1946, a definite burning schedule was maintained, with separate plots for March, May, and October burns, on both an annual and biennial basis, with an adjacent con-

Fig. 1.—Overhead photograph of control area in September, 1946, showing dense sod of blue grass (upper).

Fig. 2.—Overhead photograph of annual March burn area in September, 1946. Note decrease in blue grass and vigorous growth of *Aster*, *Ambrosia*, and other forbs.

trol plot for each burned plot. Thus one-half of all the treated areas were burned three times and one-half of them six times during the experimental period.

Effects of the fire on plant populations were determined by both permanent and temporary quadrats, laid out at random in the burn and control strips. The size of the quadrat sample varied according to the kind of plant, with one square meter areas for the grasses and 100 square feet areas for the forbs. Records were taken for the following species originally present in the plots: *Poa pratensis, Poa compressa, Agropyron repens, Ambrosia artemisiifolia, Erigeron annuus,* and *Melilotus alba,* and for the following planted prairie species: *Andropogon furcatus, Baptisia leucantha, Brauneria purpurea, Eryngium yuccifolium, Liatris aspera,* and *Solidago rigida.* In addition, *Aster ericoides* made its appearance on the area during the experiment, although it had not been planted.

RESULT

The most obvious result of the burns, regardless of time of burn, was the very great reduction in density of the blue grass cover, both of the old litter and the living vegetative stems. This is shown in the first item in Table 1, and in Figs. 1 and 2. As a consequence of this reduction in cover, considerable areas of bare ground were exposed and made available for occupancy by other plants. Annual weeds and other adventives already present in the surrounding areas increased very greatly in the burned plots (Table 1) as compared with the control areas where they were present only in traces. In the case of *Ambrosia,* at least, this increase probably came from buried seeds within the plots, since the greatest density was attained in the first year of the burn, with gradual reductions in succeeding years. Data for the biennial burns are not given here, but they showed substantially the same results.

The number of fruiting stems of the weedy grasses was not affected by the fire in the same manner as the vegetative stems, as is shown in Table 1. With the exception of the two species of *Poa* in the May burn, there was either little change or an actual increase in the density of such stems in the various burn plots. This selective effect of fire on the vegetative-reproductive ratio cannot be explained at present.

The presence and abundance of *Melilotus alba* on the experimental area was found to be conditioned both by fire and by an overwash of silt in erosion areas. All of the plants were confined to a shallow drainage wash which passed through the center of the plots. Average densities within this wash varied from a low of 133 plants per 100 square feet in the control areas to a high of 1165 plants in the same area of the March burn plot, with intermediate values for the May burn. The high densities in the March burn plot resulted in the nearly complete exclusion of all other plant species.

The planted prairie species reacted variously to the burn treatments. *Brauneria purpurea* was the only prairie species that was definitely harmed by the fire. The number of flowering plants was much higher in the control

TABLE 1.—Effect of annual burns on non-planted species in terms of number of stems per square meter.

Species	Original Number 1940	Number in 1946			Control
		March Burn	May Burn	October Burn	
Total grass stems (vegetative and fruiting)	4650	880	650	2480	4000
Agropyron repens (fruiting stems only)	1	3	31	4	4
Poa compressa (fruiting stems only)	36	100	19	194	28
Poa pratensis (fruiting stems only)	304	160	40	250	250
Ambrosia artemisiifolia	3	310	110	22	4
Aster ericoides	0	122	72	9	2
Erigeron annuus	28	64	31	464	1

than in the burned area, and the vigor of the control plants was greater, with an average flowering stalk length of 25.1 inches as compared to 19.6 inches in the burn. This species is spreading rapidly into new non-burned areas but has not established itself in any burned area. It is perhaps significant that the *Brauneria* is the only prairie species investigated whose natural range does not include southern Wisconsin. *Baptisia leucantha* showed no effect of the fire, with original numbers being maintained in all plots (Table 2 and Fig. 3). The reason for its lack of spread in either the control or burned areas is unknown. *Eryngium yuccifolium* was also unaffected by the fire with respect to maintenance of numbers of the original plants, but establishment was greatly aided by burning, concentrations of seedling as high as 375 per 100 square feet occurring in the burned areas, in contrast with negligible numbers in the control.

Liatris aspera and *Solidago rigida* exhibited still another response, in that fire seemed necessary for both maintenance and establishment (Table 2). Both have increased in numbers in the burned areas and have suffered reduction of the original plantings in the control areas. In addition, reproduction was totally lacking in the controls.

Andropogon furcatus was favorably affected by the fire in both vegetative growth and reproduction. Table 3 shows the change in certain characteristics during the experimental period for plants in the spring burn and the control plots. The figures are averages for 50 clumps in each treatment. This species was not included in the autumn burns because of the great hazard of escaping fire attendant upon experimental burning before the winter snows had matted down the luxuriant foliage. The average basal diameter of the originally planted clumps decreased slightly in the burned areas compared to the controls. In spite of this, the number and height of the flowering stems on the

burned plants was strikingly increased. The low average number of flowering stems per clump in the control was due in part to the presence of many clumps which did not flower at all in 1946. In the control plots there were no seedling plants in the areas between original clumps, while the density of seedlings in such areas reached 76.1 per square meter in the annual burn plot by 1946.

DISCUSSION

From these results it is apparent that both annual weeds and certain prairie plants are able to maintain themselves and to spread into a blue grass sod when that sod is burned repeatedly. This happens with either spring or autumn burns, on both annual and biennial schedules. Under the particular climatic and edaphic conditions of this experiment, most of the weeds and prairie plants were unable to spread successfully into the unburned blue grass sod. It appears that competition by the blue grass (including competition for water, light, and available space) is the important factor in the failure of establishment, and that fire is effective primarily because of its differential action, causing as it does a great reduction in the competitive ability of the blue grass population without adversely affecting established plants of the prairie species. Conclusive proof that fire acts in this manner through competition changes can be obtained only by the use of some other agency that will bring about the same results on the blue grass. Preliminary observations on artificially desodded areas, and on patches of blue grass weakened by white

Fig. 3.—General view of annual March burn area (left) and adjacent control (right) in September, 1946. Note abundance of *Solidago* in foreground and *Liatris* in middle of the burn plot and their near absence in the control. The strip of *Baptisia* plants crossing both plots is essentially unchanged from its original condition in 1940.

grub infestations do indicate that both weeds and prairie species are benefited, but no detailed experiments have been conducted.

From the standpoint of artificial prairie establishment it would appear that fire may be a useful and economically feasible tool in the preparation of abandoned fields for direct seeding of prairie species in certain regions where prairie is not the climatically favored formation, particularly on the eastern ecotone where higher moisture levels intensify the competition with blue grasses.

TABLE 2.—Effect of annual burns on planted prairie forbs in terms of number of individuals per 100 square feet.

Species	Original Number 1940	Number in 1946 March Burn	May Burn	October Burn	Control
Baptisia leucantha	2.6	2.5	2.4	2.6	2.6
Liatris aspera	2.6	19.1	18.4	—	1.0
Solidago rigida	2.5	30.5	—	3.6	1.3

TABLE 3.—Effect of spring burns on *Andropogon furcatus* plantings.

Treatment	Year	Aver. Diam. of Clump	Aver. Height of Flowering Stem	Aver. No. of Flowering Stems per Clump	Seedlings per Sq. Meter
Annual Burn	1941	12.3″	21.1″	—	—
	1942	11.9″	32.6″	—	—
	1946	11.5″	64.0″	87.0	76.1
Biennial Burn	1946	15.5″	56.0″	21.0	29.7
Control	1941	10.9″	16.3″	—	—
	1942	11.8″	28.4″	—	—
	1946	17.5″	44.0″	4.0	0.0

SUMMARY

Annual and biennial burns in March, May and October were made in a field of blue grass in which prairie plants had been artificially introduced. The experiments were conducted in the University of Wisconsin Arboretum at Madison, in the period from 1941 through 1946. Densities were determined annually for dominant members of the original sod, for the main weedy forbs, and for the planted prairie species.

The total density of the blue grass sod was reduced to one-fifth of the original after six years of burning. This reduction was expressed almost entirely by non-fruiting stems, since the fruiting stems were constant or slightly increased in the annual burn plots. The percentage of bare ground increased greatly on the burned areas, and the resulting decrease in competition allowed certain weedy forbs (*Ambrosia artemisiifolia, Aster ericoides,* and *Erigeron annuus*) to increase in number very markedly.

The responses of prairie plants to the fire varied according to species. *Baptisia leucantha* showed no effect of the fire, while the spread of *Eryngium yuccifolium, Andropogon furcatus, Solidago rigida,* and *Liatris aspera* was favored by the fire. *Brauneria purpurea* was reduced in both size and number by fire and, in addition, showed no spread into burned areas. This species differed from all of the other prairie species used in that it was able to spread by seed into the heavy blue grass sod of the control areas.

Notes on Wisconsin Parasitic Fungi. X.

H. C. Greene

Department of Botany, University of Wisconsin, Madison

This paper is the fortieth which has been written in the course of the last sixty-three years on the general subject of the fungi which are parasitic on plants in Wisconsin. Wm. Trelease in 1885 published a preliminary list of Wisconsin paarsitic fungi. In the next half century J. J. Davis wrote twenty-six papers on this subject. Since his death in 1937 the studies have been continued by me. The notes in this paper, unless it is stated otherwise, refer to fungi collected during 1947.

SYNCHYTRIUM sp. occurred on stems and leaves of *Viola pedatifida* collected near Lake Mills, Jefferson Co., June 9. The specimen is somewhat immature, but it seems probable that the fungus is that which has been determined as *Synchytrium aureum* Schroet. on other species of *Viola* in Wisconsin.

CHILONECTRIA CUCURBITULA (Tode) Sacc., associated with burn blight of *Pinus banksiana* and *P. resinosa,* is stated by Gruenhagen (Phytopath. 37: 771, 1947) to be pathogenic, but to be dependent for entry into the host upon some injury, primarily the punctures made by spittle bugs. It is said that in 1945 there were 64 known disease centers in 9 northeastern Wisconsin counties.

PHYLLACHORA BOUTELOUAE Rehm does not, so far as I know, produce mature asci and ascospores on *Bouteloua curtipendula* without overwintering. Associated with immature lesions, on a specimen from Attica, Green Co., are similar loculate structures in which are borne numerous elongate, hyaline, occasionally septate, subfusoid conidia, approximately 10-20 x 3-4μ.

USTILAGO MACROSPORA Desm. occurred on *Agopyron repens* at Brodhead, Green Co., July 5. Davis did not find this, but listed it for the state because of the report in the North American Flora citing Wisconsin as a host locality.

ENTYLOMA FLOERKEAE Holw. on *Floerkea proserpinacoides* is stated by Davis to be known only from eastern Wisconsin. In May, however, it was observed in great abundance near Albany, Green Co., in the south central portion of the state.

ENTYLOMA species on Compositae in North America are dealt with in a recent paper by D. B. O. Savile (Can. Jour. Research, C, 25:105-120, 1947). He considers that *Entyloma aster-sericeanum* Zundel on *Aster sericeus,* up to now reported only from Wisconsin, is *Entyloma polysporum* (Peck) Farl. He further concludes that the smut on *Rudbeckia hirta,* previously referred to *E. polysporum,* should, on account of its very thick-walled spores, be considered a distinct species. For this he employs Ciferri's name of *Entyloma davisii.*

PUCCINIA ELLISIANA Thum. I was collected on *Viola pedatifida* at Lake Mills, Jefferson Co., June 9. Trelease reported the rust on this host in 1885,

but there have been no interim collections. On August 9 at the same station uredia and telia were found on *Andropogon scoparius*. Davis made a single collection of telia on the latter host at Danbury, Burnett Co., in 1924.

UROMYCES SILPHII (Burr.) Arth. I was reported (as *Aecidium compositarum*) on *Silphium perfoliatum* by Trelease, but it has not since been collected on this host until it was found this year on radical leaves of year-old plants at Madison, June 7.

PHYLLOSTICTA sp. occurred in small quantity on leaves of *Cenchrus carolinianus* at Madison, August 11. The lesions resemble those caused by *Septoria cenchrina* J. J. Davis. The pycnidia are about 150μ diam., the conidia 5-8 x 3μ, ellipsoid or short-cylindric, straight or slightly curved. There are very few reports of Phyllostictae on Gramineae.

PHYLLOSTICTA sp. on *Aruncus sylvester*, Madison, September 30. The fungus is perhaps somewhat immature, but it seems plainly parasitic. The spots are small and irregular, frequently following the venation. They are reddish-brown and the fragile tissue is frequently ruptured. The scattered pycnidia are pale, with thin and delicate walls, subglobose, ostiolate, 65-100μ. They seem to be amphigenous, but the orientation is probably not of much significance where the leaves of the host are so very thin. The hyaline conidia range from 7-17 x 3-6μ. It seems possible that this may really be an immature *Ascochyta*, although there was no suggestion of a septum in any of the conidia observed.

PHYLLOSTICTA sp. occurred on arid, white spots on the leaves of *Grindelia squarrosa*, Town of Mt. Pleasant, Green Co., August 19. The pycnidia are subglobose, about 100μ diam., the conidia 5-8 x 2.5-3μ. It is interesting that the same fungus is on the leaves of a specimen of the same host collected by Davis at St. Croix Falls in 1914. Parasitism is doubtful.

ASCOCHYTA OXYBAPHI Trel. on *Oxybaphus nyctagineus* has been found at various stations in Dane Co. In 1885 Trelease described this species from material from Stoughton, Dane Co., and, so far as I know, it has not until now been seen since in Wisconsin. The relatively widespread occurrence of this organism in a single season, after having been unobserved in Wisconsin for more than a half century, is a puzzling thing, for *A. oxybaphi* produces conspicuous lesions on a large and commonly encountered host. It seems scarcely possible that as keen and persistent a collector as the late J. J. Davis could have collected in Wisconsin for fifty years without once having found this organism had it been present in even relatively small amount on *Oxybaphus*. One is led to wonder whether it may not be that *A. oxybaphi* and similar rarities sometimes masquerade as different "species" on other, perhaps related, hosts and only very occasionally, under special conditions, infect the hosts under consideration.

ASCOCHYTA sp. on *Cynoglossum officinale*, Columbia Co., Poynette, July 20. Unfortunately the material is scanty. The spots are large, irregular, immarginate, and dull brown. The pycnidia are gregarious, thin-walled, epiphyl-

lous, about 150μ diam. The conidia are 8-10 x 2.5-3μ, with a greenish tinge and median septum. There do not seem to be any other reports of *Ascochyta* on this host.

SEPTORIA ANDROPOGONIS Davis f. SPOROBOLICOLA Sprague which infects leaves of *Sporobolus heterolepis* is described (Mycologia 35:260, 1943) as differing from typical *S. andropogonis* in having larger pycnidia (up to 150μ diam. as compared to 100μ for *S. andropogonis*) and smaller, more or less circular, non-striate lesions. A fungus which is in this complex was collected on the same host at Lake Mills, Jefferson Co., August 9. Here the pycnidia are very large, up to 250μ diam, or more, while the sporules are up to 65μ long, as compared to about 50μ for both *S. andropogonis* and the f. *sporobolicola*. The lesions vary from ellipsoid, with not more than two or three pycnidia, to definitely striate with a number of pycnidia. Sprague has determined this as the f. *sporobolicola* and states that experience has shown that the size range is decidedly greater than that specified in the description. I have referred two other Wisconsin specimens on *S. heterolepis* to *Septoria andropogonis* rather than to the f. *sporobolicola* because they have definitely striate lesions and pycnidia and conidia which are close to the size given for the species proper.

SEPTORIA on *Solidago* in Wisconsin presents a confusing assemblage of forms. Field experience leads me to suspect that *Septoria fumosa* Peck, *S. davisii* Sacc., *S. angularis* Dearn. & Barth., *S. solidaginicola* Peck, and perhaps others, are but variable forms of one organism. A case in point is *Septoria angularis* Dearn. & Barth., described on *Solidago latifolia* collected in June, and distributed as Fungi Columbiani 4875. Wisconsin material on the same host, collected July 1, 1945, shows close resemblance to the Dearness specimen of *S. angularis* and was so determined. Specimens on the same host at the same station, collected in late September 1947, seem plainly referable to *S. solidaginicola* Peck, with angular arid spots and small, black, scattered pycnidia. Since, however, the principal difference between the early and late season collections is in the aridity of the spots, it seems doubtful whether there is any real distinction. In connection with the original description of *S. angularis* Dearness and Bartholomew state "This comes near *S. fumosa* Peck on *Solidago canadensis* L. Affected leaves seem easily distinguishable and yet it might have been better to consider this a species variety of *S. fumosa*."

HENDERSONIA CRASTOPHILA Sacc. occurs on leaves of *Sporobolus heterolepis* collected at Big Spring, Adams Co., July 7. Det. R. Sprague. The *Hendersonia* is closely associated with *Selenophoma*, a definite parasite, but it seems likely that the former developed saprophytically.

VERMICULARIA (COLLETOTRICHUM) PHLOGINA Fairm. on *Phlox divaricata* from Spring Grove, Green Co., August 21, seems to be a well-defined and characteristic species, but its parasitism is doubtful.

MARSONIA GLOEODES H. C. Greene, described on *Fraxinus americana* from Madison (Trans. Wis. Acad. Sci. 38:231, 1946), has been found

again on the same host at Canyon Park near Dodgeville, Iowa Co., August 14. Some of the latter material of this distinctive species is accompanied by darkened stromatic bodies which contain very large numbers of spermatium-like microconidia.

RAMULARIA ARISAEMATIS Ell. & Dearn. on *Arisaema triphyllum* is regarded by Saccardo as a dubious species since there is no mention of conidiophores in the description. It is stated that the tufts of conidia are borne on ovate, zonate, brownish spots and that the conidia are mostly sessile. A fungus which is similar to that of Ellis and Dearness occurred on the same host near Marshall, Dane Co., June 9. The hyaline conidia are numerous, cylindrical, about 17-200 x 3.5-4.5μ. In addition to these the spots are beset with setae about 50μ long, somewhat swollen at the base, smoky below, paler above, and strongly tapered to a narrow tip. There is no evidence that the conidia are borne on these, or that there is any connection. It is questionable whether this is parasitic.

CERCOSPORA CORDATAE Chupp & Greene was published in my Notes VI (Trans. Wis. Acad. Sci. 36:265, 1944) as a new species on *Zizia cordata* (*aptera*) and later reported on *Zizia aurea*. A recent collection of *Cercospora* on *Thaspium trifoliatum* var. *flavum* (*aureum*) focused my attention on *Cercospora thaspiicola* J. J. Davis, based on material on this host from South Wayne, in Lafayette Co. Microscopic comparison indicates that the specimens on *Thaspium* and *Zizia* are identical. The name *Cercospora cordatae* is therefore a synonym.

A Basidiomycete of uncertain identity and affinities occurred as an obvious parasite on the leaves of *Aster prenanthoides* at Canyon Park near Dodgeville, Iowa Co., June 28. The fungus is amphigenous, mostly hypophyllous, in erumpent snowy-white tufts of characteristic basidiomycetous aspect. The small, fleck-like tufts are grouped together in poroid fashion, appearing reticulate under the hand lens. The hyaline basidiospores are falcate or subfusoid, about 10-15 x 3-3.5μ, and many are still attached to the sterigmata.

Powdery mildews which were undetermined, but were, of course, unquestionably parasitic, occurred on: *Hedeoma hispida*, Dane Co., Pine Bluff, July 1; on *Pentstemon digitalis*, Green Co., Dayton, July 5; on *Solidago uliginosa*, Dane Co., Madison, October 20; on *Cacalia atriplicifolia*, Rock Co., Tiffany, July 11; on *Hieracium scabrum*, Dane Co., Madison, July 30.

ADDITIONAL HOSTS

The fungi mentioned have not before been reported as occurring in Wisconsin on the hosts that are cited.

SYNCHYTRIUM AUREUM Schroet. on *Cardamine bulbosa*. Iowa Co., Arena, May 22. Also on *Viola "cucullata"*. Dane Co., Mazomanie, May 22. The latter collected by C. G. Shaw. The host is a large stemless blue violet. In close proximity *Viola pallens* was heavily infected by the same parasite. It has already been reported as a host for *S. aureum* in Wisconsin. Davis, who col-

lected many specimens on a number of different hosts, considered that this is probably an "aggregate" species. The current material is similar to most of the specimens that Davis filed under *S. aureum*.

PLASMOPARA HALSTEDII (Farl.) Berl. & DeToni on *Ratibida* (*Lepachys*) *pinnata*. Rock Co., Milton Junction, July 11; also Iowa Co., Arena, July 19. The Arena specimen collected by C. G. Shaw.

SPORODINIA GRANDIS Link on *Polyporus sulphureus*. Dane Co., Madison, July 12.

ERYSIPHE GRAMINIS DC. Conidia only on *Koeleria cristata*. Dane Co., Madison, June 18.

SPHAEROTHECA HUMULI (DC.) Burr. var. FULIGINEA (Schl.) Salm. on *Pedicularis canadensis*. Walworth Co., East Troy, September 6.

CLAVICEPS PURPUREA (Fr.) Tul. Sclerotia on *Agropyron trachycaulum* var. *glaucum* (*A. subsecundum* of Hitchcock). Waukesha Co., Eagle, July 31.

PHYLLACHORA GRAMINIS (Pers.) Eckl. on *Elymus riparius*. Grant Co., Platteville, September 14, 1940. Host coll. & det. N. C. Fassett. On a phanerogamic specimen in the University of Wisconsin Herbarium.

COLEOSPORIUM CAMPANULAE (Pers.) Lév. II on *Campanula rapunculoides*. Rock Co., Janesville, July 17. Arthur's Manual records the rust on this host only from the eastern states. Literally every leaf of every plant in a large roadside colony was heavily infected.

PUCCINIA RUBIGO-VERA (DC.) Wint. I on *Anemonella thalictroides*. Dane Co., Deerfield, June 9. Also on *Actaea rubra*. Sauk Co., Parfrey's Glen, June 24. III on *Agropyron trachycaulum* var. *glaucum*. Waukesha Co., Eagle, July 31. It is quite probable that some or all of the earlier reports of this rust on *Argopyron tenerum* in Wisconsin should be referred to *A. trachycaulum* var. *glaucum*.

PUCCINIA ANDROPOGONIS Schw. I on *Pentstemon tubaeflorus*. Burnett Co., Webster, August 6, 1945. Coll. J. W. Thomson.

PUCCINIA EXTENSICOLA Plowr. I on *Aster oblongifolius* var. *angustatus*. Columbia Co., Black Hawk's Lookout near Prairie du Sac, June 21. This seems to be the first report for this host. On *Aster prenanthoides*. Sauk Co., Parfrey's Glen, June 24. In the treatment of the Uredinales in the North American Flora Wisconsin is given as the sole locality for the rust on *A. prenanthoides*, but Davis does not mention it in his notes and there was no specimen in the University Herbarium. Also on *Krigia virginica*. Dane Co., Madison, June 2.

PHYLLOSTICTA BOEHMERIICOLA J. J. Davis on *Laportea canadensis*. Dane Co., Mazomanie, August 14. On the coarser, thicker leaves of *Laportea* the spots are more sharply defined, with darker borders, than in the type specimen on *Boehmeria*. The pycnidia are almost superficial.

PHYLLOSTICTA PHASEOLINA Sacc. on *Apios tuberosa*. Dane Co., Madison, September 30. The spots are conspicuous, but the pycnidia are not as prominent nor as closely clustered as in specimens on *Strophostyles helvola*.

PHYLLOSTICTA VIOLAE Desm. on *Viola pedatifida*. Dane Co., Madison, July 12. The conidia are mostly 9-12 x 2.5-3μ, cylindric or subfusoid. A number of mounts from different leaves were examined and in no instance was there any evidence of even incipient septation. The fungus appears well matured. The host was destructively attacked and entire lobes of the leaves had died back.

PHYLLOSTICTA HORTORUM Speg. on *Solanum carolinense*. Columbia Co., Dekkora, July 20. Placed here on the basis of the conidial dimensions which are 5-7 x 2.5-3μ. I suspect that *Phyllosticta solani* Ell. & Mart. (conidia 9 x 2μ) is a form of the same thing.

PHYLLOSTICTA LIATRIDIS J. J. Davis on *Liatris cylindracea*. Dane Co., Madison, June 18.

DARLUCA FILUM (Biv.) Cast. on *Puccinia silphii* Schw. on *Silphium terebinthinaceum*. Jefferson Co., Palmyra, July 31.

ASCOCHYTA GRAMINICOLA Sacc. on *Bromus japonicus*. Dane Co., Madison, June 18. Conidia mostly 10-14 x 3.5-4μ. Plainly not *Stagonospora bromi* Smith & Ramsb.

ASCOCHYTA VIOLAE Sacc. & Speg. on *Viola pedatifida*. Jefferson Co., Lake Mills, June 9. Reported by Trelease in 1885 on *Viola pubescens* from Madison. There are no interim collections in the herbarium. In the present specimen the pycnidia seem to fall into two size groups, but the conidia are consistently of the dimensions indicated in the description, 15-18 x 3.5-4μ. The larger pycnidia are up to 200μ diam. and are closely crowded on the spots on which they occur, while the smaller pycnidia are up to 100μ diam. and are only gregarious. Although the large and small pycnidia are not on the same spots, I feel there can be little doubt that but the one organism is present. In several instances pycnia of *Puccinia ellisiana* Thum. are closely associated with the *Ascochyta* on the same spots.

ASCOCHYTA COMPOSITARUM J. J. Davis on *Echinacea* (*Brauneria*) *purpurea*. Dane Co., Madison, July 3. This is the small-spored form which Davis described as var. *parva*, with spores 10-15 x 2.5-3.5μ. Specimens are still filed thus in the herbarium, but in his "Parasitic Fungi of Wisconsin," p. 72, Davis includes this with the species. The specimen on *Echinacea* is scanty, but seems well-defined.

STAGONOSPORA ARENARIA Sacc. on *Oryzopsis racemosa*. Green Co., New Glarus, July 21. The conidia are mostly 3-septate, 20-30 x 3-4μ. The pale brown lesions are narrow with the pycnidia arranged subseriately. Some of the lesions have paler, arid centers. Davis reported this fungus on *Elymus canadensis*, and Sprague considers that a specimen on *Phalaris arundinacea*, col-

lected at Devils Lake in 1913 and determined by Davis as *Stagonospora intermixta* (Cke.) Sacc., is better referred to *S. arenaria.*

STAGONOSPORA MELILOTI (Lasch) Petr. on *Trifolium repens* (cult.). Dane Co., Madison, May 24. Coll. & det. J. G. Dickson. The host is the giant white Ladino clover.

STAGONOSPORA ZONATA J. J. Davis on *Asclepias ovalifolia.* Dane Co., Madison, September 10. Most of the sporules are 1- and 2-septate only, but the characteristic zonation is well-marked. Also on *Asclepias viridiflora* (*Acerates*). Columbia Co., Otsego, September 17. Some of the conidia are 7-septate and up to 45μ long. It seems clear that *S. zonata* is a single, although quite variable species. The zonate lesions are typical.

SEPTORIA BROMI Sacc. on *Bromus japonicus.* Dane Co., Madison, June 20.

SEPTORIA SII Rob. & Desm. on *Chaerophyllum procumbens.* Rock Co., Avon, May 26. The spotting is not well-defined, but the fungus is similar to specimens on various hosts filed under *S. sii.* The slender sporules are slightly curved, about 30-40 x 1.5μ, and the globose pycnidia are from 65-100μ. diam. There is considerable morphological variation in the forms which have been put under this species, but it seems scarcely sufficient to warrant their separation as entities.

SEPTORIA PENTSTEMONIS Ell. & Ev. on *Pentstemon tubaeflorus.* Burnett Co., Webster, August 6, 1945. Coll. J. Thomson. Closely associated with aecia of *Puccinia andropogonis* Schw.

SEPTORIA INCONSPICUA B. & C. on *Plantago lanceolata.* Dane Co., Madison, August 8. The beaked pycnidia are about 60μ diam., the sporules 20-25μ long.

SEPTORIA ASCLEPIADICOLA Ell. & Ev. on *Asclepias phytolaccoides* .Dane Co., Madison, August 6.

SEPTORIA EUPATORII Rob. & Desm. on *Eupatorium altissimum.* Rock Co., Tiffany, July 17. This fungus also occurs on a specimen of *E. altissimum,* in the phanerogamic section of the University of Wisconsin Herbarium, from Potosi, Grant Co., collected September 16, 1935, by N. C. Fassett. On this host the spots are rounded, 1-2.5 mm. diam., centers pallid or fuscous, with narrow, raised, yellowish inner margin, surrounded by a dark green border about 0.3 mm. wide. There are from one to half a dozen spots per leaf. They are plainly visible on both leaf surfaces and are usually greenish below. This differs somewhat from specimens on *Eupatorium perfoliatum* that I have also referred to *S. epuatorii.* There the spots are frequently smaller and angled.

SEPTORIA FUMOSA Peck on *Solidago juncea.* Dane Co., Madison, June 12. Also on *Solidago missouriensis* var. *glaberrima.* Dane Co., Paoli, June 26.

SEPTORIA ERIGONERIS Peck on *Erigeron pulchellus.* Sauk Co., Parfrey's Glen, June 24. The sporules are mostly short, not over 25μ long.

SEPTORIA CIRSII Niessl on *Cirsium hillii.* Dane Co., Westport, June 30. Seemingly the first report of a parasite on this uncommon host. Also on *Cirsium undulatum.* Dane Co., Madison, July 2. Seymour does not list *S. cirsii* on the latter host.

SELENOPHOMA EVERHARTII (Sacc. & Syd.) Sprague & Johnson on *Bouteloua curtipendula.* Green Co., Attica, August 21. Det. R. Sprague. This also has been reported from Wisconsin on *Calamagrostis canadensis* as *Septoria everhartii* Sacc. & Syd.

DILOPHOSPORA ALOPECURI Fr. an *Leersia oryzoides.* Dane Co., Madison, September 7. The infected plants were in close proximity to *Phalaris arundinacea* bearing the same parasite. This has also been found on *Calamagrostis canadensis* in Wisconsin.

COLLETOTRICHUM GRAMINICOLUM (Ces.) Wils. on *Hierochloe odorata.* Green Co., Brodhead, May 19. So far as I have been able to determine there have been no previous reports of *C. graminicolum* on this host.

COLLETOTRICHUM VIOLAE-ROTUNDIFOLIAE (Sacc.) House on *Viola pedatifida.* Jefferson Co., Lake Mills, May 24. Not listed in Seymour on this host.

COLLETOTRICHUM SOLITARIUM Ell. & Barth. on *Solidago altissima.* Green Co., Town of Exeter (Sect. 32), August 27.

ELLISIELLA CAUDATA (Peck) Sacc. on *Andropogon scoparius.* Jefferson Co., Lake Mills, August 9. *E. caudata* has also been found on *Andropogon furcatus, Sorghastrum nutans,* and *Sporobolus heterolepis* in Wisconsin.

RAMULARIA PRATENSIS Sacc. on *Rumex acetosella.* Dane Co., Madison, June 12. Reported on this host by Oudemans, but not listed by Seymour.

RAMULARIA ARVENSIS Sacc. on *Potentilla arguta.* Lafayette Co., Red Rock, June 10.

CLADOSPORIUM ASTERICOLA J. J. Davis on *Solidago uliginosa.* Columbia Co., Otsego, September 17. Apparently the first report of *C. astericola* on this host.

SCOLECOTRICHUM GRAMINIS Fckl. on *Glyceria grandis.* Dane Co., Mazomanie, August 14. The lesions are rather poorly defined, but the parasite is characteristic.

HELMINTHOSPORIUM SATIVUM Pamm., King & Bakke on *Elymus canadensis.* Dane Co., Madison, August 24. Closely associated, on similar lesions and appearing parasitic, is a species of *Leptosphaeria* which approximates *Leptosphaeria elymi* Atk. in its dimensions, although the asci are somewhat longer than those of *L. elymi* (65μ instead of 50μ).

CERCOSPORA VIOLAE Sacc. on *Viola pedatifida.* Dane Co., Madison, September 5, 1944.

CERCOSPORA GRISEA Cke. & Ell. on *Polygala polygama*. Dane Co., Madison, July 28. The lesions on this host are better defined, but the development of the fungus is less profuse than in earlier collections on *Polygala sanguinea*. *C. grisea* does not appear to have been previously reported on *P. polygama*.

CERCOSPORA INCARNATA Ell. & Ev. on *Asclepias ovalifolia*. Green Co., Brodhead, August 21. The slender, dilutely fuliginous conidia are mostly from 50-70μ long by 3-4μ at the base, but one was measured that was 100μ.

CERCOSPORA PLANTAGINIS Sacc. on *Plantago lanceolata*. Dane Co., Madison, August 14.

CERCOSPORA BRIAREUS Ell. & Ev. on *Asclepias hirtella* (*Acerates floridana*). Columbia Co., Otsego, September 17. The rather long, nodulose conidiophores verge on the type of those of *Cercospora clavata* (Ger.) Cke., but the slenderly obclavate conidia are assuredly not of that species. It is interesting to note that, although the taxonomists have decided that *Acerates* is properly united with *Asclepias*, word does not seem to have reached the Cercosporae and they continue to differentiate between the two genera.

ADDITIONAL SPECIES

The species listed here have not hitherto been reported as occurring in Wisconsin.

PHYSODERMA GRAMINIS (Busgen) Fischer on *Agropyron repens*. Dane Co., Madison, July 1947. Coll. & det. J. G. Dickson.

PIPTOCEPHALUS parasitic on Mucoraceae. The following species have been cultured and determined by C. W. Hesseltine of the University of Wisconsin Department of Botany:

P. CRUCIATA Van Tiegh. on *Mucor*. sp. which was growing on rabbit dung. Dane Co., Madison, May 24, 1945.

P. REPENS Van Tiegh. & Le Monnier on *Circinella* sp. growing on Brazil nuts in a Madison market. It is, of course, doubtful whether this can be considered a "Wisconsin species."

P. CYLINDROSPORA Bainier on *Mortierella* sp. collected at Devils Lake, Sauk Co., June 1946. Zygospores were produced in abundance.

PERONOSPORA NARBONENSIS Gaumann on *Vicia americana* and PERONOSPORA DEBARYI Salmon & Ware on *Urtica gracilis*. C. G. Shaw, who has made a special study of the Peronosporaceae of Wisconsin, considers the mildew on *Vicia americana* to be distinct from *Peronospora viciae* (Berk.) DeBary. He also finds, upon examination of the Trelease specimen on which the report of *Peronospora urticae* (Lib.) DeBary in Wisconsin is based, that the fungus must be referred to *P. debaryi*.

AECIDIUM CAMPANULASTRI G. W. Wilson on *Campanula americana*. Iowa Co., Canyon Park near Dodgeville, June 28. Reported in Arthur's Manual from Iowa and Minnesota.

UROMYCES BICOLOR Ellis II, III on *Allium canadense*. Walworth Co., Lake Geneva, Wychwood, May 23. Coll. C. G. Shaw. Arthur's Manual lists Mass., N. Y., Mo., and Tex. as host localities.

USTILAGO CRUS-GALLI Tracy & Earle on *Echinochloa crus-galli*. Dane Co., Madison, October 4. Coll. & det. M. J. Thirumalachar.

ENTYLOMA GUARANITICUM Speg. on *Echinacea* (*Brauneria*) *pallida*. Rock Co., Janesville, July 17. Det. D. B. O. Savile. The fungus was tentatively identified as *E. polysporum* (Peck) Farl., but Savile detected conidia and conidiophores, which *E. polysporum* does not produce. He states that the spores are definitely too large and too thick-walled for *E. compositarum*, and that the material is identical with that of *E. gauraniticum* on *Bidens pilosa* from Florida.

Phyllosticta pentstemonicola sp. nov.

Maculis irregularibus, pallido-brunneis, marginibus rubiginosis, angustis; pycnidiis amphigenis, fuscis, subglobosis, ostiolatis, 65-110μ diam.; conidiis hyalinis, biguttulatis, subcylindraceis, 10-15 x 4-5μ.

Spots irregular, pale brown, margins rust-colored, narrow; pycnidia amphigenous, fuscous, subglobose, ostiolate, 65-110μ diam.; conidia hyaline, biguttulate, subcylindric, 10-15 x 4-5μ.

On living leaves of *Penstemon hirsutus*. Madison, Dane County, Wisconsin, U. S. A., August 12, 1947.

The lesions are very irregular in size and shape, but are mostly somewhat elongate, sometimes with wavy margins. On the larger lesions the pycnidia are mostly about the periphery. The affected tissue is thin and translucent, but there is no indication of primary insect activity.

Phyllosticta cacaliae sp. nov.

Maculis irregularibus, plerumque elongatis, exaridis, marginibus fuscis; pycnidiis epiphyllis, dispersis, globosis vel subglobosis, nigris, muris tenuibus, ostiolatis, 175-225μ diam.; conidiis hyalinis, granulosis, plerumque biguttulatis, cylindraceis, 4-6 x 1.5-2μ.

Spots indefinite, mostly irregularly elongate arid areas with darker borders; pycnidia epiphyllous, scattered, globose or subglobose, black, thin-walled, ostiolate, 175-225μ diam.; conidia hyaline, granular, mostly biguttulate, cylindric, 4-6 x 1.5-2μ.

On living leaves of *Cacalia tuberosa*. Madison, Dane County, Wisconsin, U. S. A., August 7, 1947.

The light colored arid areas are principally oriented along the midrib and are, like the pycnidia in them, epiphyllous. On the reverse the affected tissue is merely fuscous.

ASCOCHYTA BOHEMICA Kab. & Bub. on *Campanula rapunculoides*. Dane Co., Madison, July 19. Microscopic examination of sections shows that the fruiting structures are true pycnidia, although they are very thin-walled and flattened. It seems probable that *A. bohemica* and *Marsonia campanulae* Bres. & Allesch. are identical.

Apiocarpella minor R. Sprague sp. nov.

Maculis ellipticis vel linearibus griseis vel pallido-flavis, centris subalbidis interdum, marginibus purpureis; pycnidiis ellipticis vel subglobosis, erumpentibus, brunneis, parenchymaticis, ostiolatis, 90-165 x 80-125μ; pycnosporulis ellipsoideo-ovatis, basibus acutis, septatis excentris (loculis superis majoribus, loculis inferis parvis, appendiculiformis), hyalinis, 13-17 x 3.7-5μ.

Spots elliptical or linear, gray or pale yellowish, sometimes with centers sordid whitish, margins purplish; pycnidia elliptical or subglobose, erumpent, brown, parenchyma-like, ostiolate, 90-165 x 80-125μ; pycnospores ellipsoid-ovate with acute base, excentrically septate (the upper locule larger, the lower smaller, appendiculiform) hyaline, 13-17 x 3.7-5μ.

On living leaves of *Calamagrostis canadensis*. Madison, Dane County, Wisconsin, U. S. A. Coll. H. C. Greene, July 22, 1947.

Stagonospora polytaeniae sp. nov.

Maculis orbicularibus, leviter zonatis, immarginatis, pallido-brunneis; pycnidiis gregariis vel dispersis, plerumque amphigenis, subglobosis, olivaceis, muris tenuibus, 100-200μ diam., plerumque 125-150; conidiis hyalinis, cylindraceis, 1-2-septatis, 15-30 x 5-7μ.

Spots orbicular, faintly zonate, immarginate, pale brown; pycnidia gregarious or scattered, usually amphigenous, subglobose, olivaceous, thin-walled, 100-200μ diam., mostly 125-150μ; conidia hyaline, cylindrical, 1-2-septate, 15-30 x 5-7μ.

On living leaves of *Polytaenia nuttallii*. Burke, Dane County, Wisconsin, U. S. A., June 30, 1947.

A good many of the spots impinge on the margins of the narrowly dissected leaves, in which case, of course, their shape is not that of a full orb.

The only other species of *Stagonospora* on a member of the Umbelliferae of which I am aware is *S. cryptotaeniae*, described by me on *Cryptotaenia canadensis*.

SEPTORIA MACROPODA Pass. on *Poa annua*. Dane Co., Madison, June 2. This is by no mean the first collection of this fungus in Wisconsin, but Davis reported it as *Septoria graminum* Desm. Sprague, in his monograph of the graminicolous Septoriae, considers this species and its varieties in great detail.

SEPTORIA HEDEOMAE Dearn. & House on *Hedeoma hispida*. Dane Co., Pine Bluff, July 1. Coll. C. G. Shaw & H. C. Greene. This is described (N. Y. State Museum Bull.—Rept. State Botanist, 1917, p. 57) as having spores 24-33 x 1μ in specimens on *Hedeoma pulgeoides*. In the case of *H. hispida*, however, many of the spores are larger, up to 50 x 1.5μ. Not listed in Seymour on *H. hispida*.

SEPTORIA GAILLARDIAE Ell. & Ev. on *Gaillardia pulchella* var. *picta*. Dane Co., Norway Grove, July 20. Many of the sporules are shorter than the lower limit of 45μ indicated in the description and few, if any, are over 50μ.

Septoria parvimaculans sp. nov.

Maculis parvis, circulis, 0.5-1 mm. diam., pallido-brunneis, marginibus elevatis; pycnidiis 50-65μ diam., subglobosis, ostiolis latis, fuligineis, pseudoparenchymaticis, fere superficialibus, epiphyllis, gregariis; conidiis hyalinis, continuis, indistincte granulosis, plerumque curvis forte, 30-50 x 1.5μ.

Spots small, rounded, 0.5-1 mm. diam., pale brown, margin raised; pycnidia 50-65μ diam., subglobose, widely ostiolate, sooty, pseudoparenchymatous, almost superficial, epiphyllous, gregarious; conidia hyaline, continuous, faintly granular, mostly strongly curved, 30-50 x 1.5μ.

On living leaves of *Kuhnia eupatorioides*. Tiffany, Rock County, Wisconsin, U. S. A., July 17, 1947.

The number of spots per leaf is variable, from one to not more than half a dozen. Despite the widely gaping ostioles this seems to be a good *Septoria* and not referable to that heterogeneous assemblage of doubtful forms which have been placed under the "genus" *Phleospora*.

Gloeosporium brunneo-maculatum sp. nov.

Maculis brunneis, centris fuscis, marginibus pallidioribus, 1-3 mm. diam., interdum confluentibus; acervulis brunneolis, subcuticularibus, erumpentibus, epiphyllis, gregariis, 80-110μ diam.; conidiophoris hyalinis, brevibus, late conicis, 5μ altis, confertis; conidiis hyalinis, rectis vel curvatis leviter, 14-20 x 3-3.5μ.

Spots brown, centers fuscous, with paler margins, 1-3 mm. diam., sometimes confluent; acervuli brownish, subcuticular, pustular-erumpent when fresh, epiphyllous, gregarious, 80-110μ diam.; conidiophores hyaline, short, broadly conical, about 5μ high, crowded; conidia hyaline, straight or slightly curved, 14-20 x 3-3.5μ.

On living leaves of *Trillium grandiflorum*. Madison, Dane County, Wisconsin, U. S. A., May 29, 1947.

This differs from *Gloeosporium trillii* Ell. & Ev. in color of spots and acervuli, and in the dimensions of the conidia. Despite the elongate conidia, this seems to be a definite example of *Gloeosporium*, with no suggestion of *Colletotrichum* or *Marsonia*. Following Davis' lead, I earlier referred some specimens of this fungus to *Phyllosticta trillii* Ell. & Ev., although I expressed doubt as to the correctness of including them in *Phyllosticta*, and suggested that they would be better placed under *Gloeosporium*, although not under *G. trillii* which was described on *Trillium sessile* from California. Davis collected *G. brunneo-maculatum* on *Trillium cernuum* at Radisson, Sawyer Co., in 1906. He determined it as *Phyllosticta trillii*, although he pointed out that it did not well match the description and that the "pycnidia" were hemispherical (Trans. Wis. Acad. Sci. 16(2):762, 1910). A third Wisconsin host for the fungus is *Trillium flexipes* Raf. (*T. declinatum*), with specimens from Mt. Vernon, Dane Co., and Milford, Jefferson Co.

GLOEOSPORIUM RUBICOLUM Ell. & Ev. on *Rubus* sp. (probably *R. allegheniensis*). Juneau Co., Rocky Arbor Roadside Park, September 20.

Cladosporium baptisiae sp. nov.

Maculis nullis; amphigenis, subcuticularibus, plerumque in venis, maxime in costis centris; conidiophoris fasciatis, simplicibus, olivaceo-brunneis fuscis, 1-septatis vel continuis, longitudinibus variis, plerumque brevibus, 10-35 x 3.5-5μ; conidiis olivaceis, granulosis, subcylindraceis vel fusoideis, 1-septatis, 17-20 x 4-7μ.

Spots none; amphigenous, subcuticular, mostly on veins, especially the midribs; conidiophores tufted, simple, dark olivaceous brown, 1-septate or continuous, length variable, mostly short, 10-35 x 3.5-5μ; conidia olivaceous, granular, subcylindric or fusoid, 1-septate, 17-20 x 4-7μ.

On living leaves of *Baptisia leucophaea*. Madison, Dane County, Wisconsin, U. S. A., July 14, 1947.

Although it causes no distortion or noticeable discoloration of the host the fungus seems nevertheless to be parasitic. I do not find any other report of *Cladosporium* on *Baptisia*.

CERCOSPORA HOUSTONIAE Ell. & Ev. on *Houstonia longifolia*. Green Co., Town of Sylvester (Sect. 1), July 5. Some of the conidia are up to 65μ long, instead of the upper limit of 40μ given in the description, but in all other respects there is close correspondence. Seemingly the first report on *H. longifolia*.

CERCOSPORA ELONGATA Peck on *Dipsacus sylvestris*. Milwaukee Co., Wauwatosa, August 31, 1938. Coll. R. W. Pohl. On a phanerogamic specimen in the University of Wisconsin Herbarium.

CERCOSPORA ASCLEPIADIS Ell. on *Asclepias tuberosa*. Dane Co., Madison, September 9. Det. Chas. Chupp, who states that this is the only species on *Asclepias* having hyaline acicular conidia.

A Study of the Distribution of Epiphytic Plants in New York

Babette I. Brown
Department of Botany,
University of Rochester, Rochester, N. Y.

CONTENTS

Introduction

Plants have been classified into four groups with respect to their habitat: water plants (hydrophytes), stone plants (lithophytes), land plants and epiphytes. Gradations exist between members of these groups so that there can be no absolute line of demarcation between them. The present study is concerned primarily with plants of the fourth group—the epiphytes—which Goebel (1893) defined as plants which are attached to the outer surface of other plants. They secure nothing from the living tissue of the "host" but perhaps utilize some of the decomposition products of the outer, dead bark layers. Epiphytes are not limited to particular plants but as a result of their location are at a disadvantage for obtaining water and mineral nutrients.

Kerner (1902) defined epiphytes as plants which grow attached to other plants or to animals. They are, furthermore, in his regard, plants which grow against the bark of living trees and have no connection with the ground so that they have no means of obtaining nutriment from it. They maintain themselves through the absorption of nutriment from the substratum through their organs of attachment—roots, rhizoids or hyphae—which either grow straight into the bark or are merely adnate to its surface.

Epiphytes have been defined as those plants which pass through their entire course of development, from germination to fruiting, on another plant without nourishing themselves, as do parasites, at the expense of their host (Ochsner, 1928). Anteceding and closely paralleling the above definition is that of Schimper (1903) which states, "Epiphytes are plants that germinate on other plants and grow without obtaining nutriment at the cost of the substance of their host. In this they differ from true parasites with which they are often confounded."

Investigations and studies of the plants which qualify as epiphytes reveal that the group comprises a wide morphological variety. For their classification

Schimper (1903) proposes four categories which he calls the proto-epiphytes, the hemi-epiphytes, the nest epiphytes, and the tank epiphytes. The proto-epiphytes include a varied group of more or less xerophilous plants compelled to acquire their nourishment from the surface of the supporting plant or structure and directly from the atmosphere. Each of the larger groups of the plant kingdom is represented among the proto-epiphytes which range from orchids, ferns, bryophytes, fungi, and lichens to algae. Hemi-epiphytes, a smaller and less varied group, are plants like the members of the genus *Ficus* that germinate on trees and pass through their earlier stages thereon though they finally develop soil roots which function as do those of typical terrestrial plants. Certain tropical ferns, such as *Asplenium nidus,* illustrate the so-called nest epiphytes which develop structures in which water and humus accumulate. Tank epiphytes have all the activities associated with absorption and nutrition carried on by their leaves; their roots if they are developed at all, serve only for anchorage. Tropical Bromeliads, species of *Tillandsia, Nidularium,* etc., exemplify this group.

In the present study only the proto-epiphytes have been considered. As has been pointed out, they are the most numerous and most varied of the epiphytic categories. Although the epiphytic vegetation in the tropical forest is most luxuriantly developed and the entire gamut of epiphytic plants in the plant kingdom may be found on the leaves, trunks and branches of the forest trees, this investigation deals solely with epiphytic species of the temperate zone including lichens, algae, liverworts, mosses and ferns.

True epiphytes, according to Ochsner (1928) 'may consist of obligate or facultative species. The latter are found on substrata of rock, dead wood, earth, etc., a well as on other plants; the former occur only as epiphytes on other plants. Pseudo-epiphytes are such species as may occur accidentally or occasionally as epiphytes though they possess none of the adaptations to the epiphytic mode of life which Oschner maintains are exhibited by true epiphytes, conceding, however, that there are all degrees of gradation between pseudo- and true epiphytes.

Schimper and others designate the plant on which an epiphyte grows as its "host." Ochsner objects to the use of this term on the ground that it has already been applied to the organism which harbors a parasite. For referring to epiphyte-bearing plants he proposes the term *Trägerpflanze,* support or carrier plant (phorophyte).

Support or carrier plants, considered synonymous with "hosts," in the present investigation, have been limited to terrestrial, woody species, principally trees but in a few cases, shrubs.

Ochsner (1928) does not consider true epiphytes those plants which as typical inhabitants of the forest floor have grown up over prominent roots and the bases of tree stumps; he limits epiphytes to those species which inhabit the crown, crown base, trunk, trunk base and stump of trees. In this study the bark of all these portions has been examined for epiphytic vegetation.

The term epiphyte herein signifies those lichens, algae, liverworts, mosses and ferns of corticolous habit, without soil connections, which complete their

life cycle supported on woody hosts from which they are nutritionally independent except for the moisture or minerals obtained through superficial absorption from the surface of their substratum.

ACKNOWLEDGMENTS

The writer wishes to express her deep appreciation to Professor W. C. Muenscher of Cornell University. She is indebted to him for advice and direction in the execution of this study and for making possible the opportunities to carry out the field work.

She is indebted to Miss Joyce Hedrick (Mrs. Volney H. Jones) of the University of Michigan for verifying certain specimens of lichens and to Professor A. LeRoy Andrews of Cornell University for verifying a number of the mosses.

Methods and Procedure

The present report of the distribution of epiphytes in New York State is based on field studies made in 1944 and 1945. The main objects of the project were to determine the general distribution of the more common epiphytes and to ascertain if possible whether their distributions are correlated with physiographic regions, altitude, climatic regions, habitats or hosts.

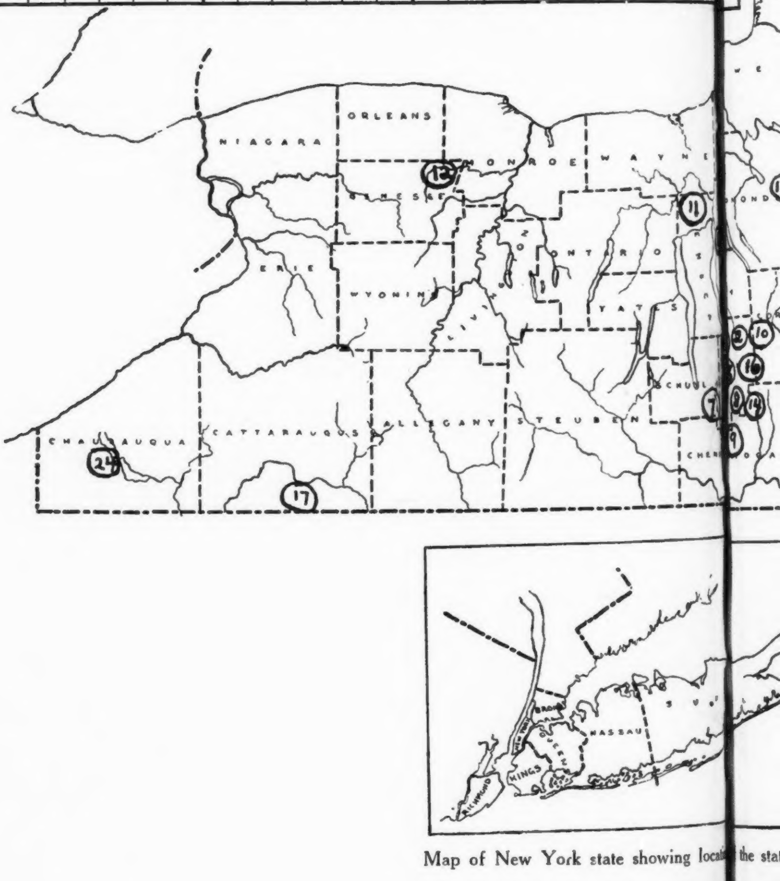
Twenty-five stations, representing widely separated and different regions, were selected for special study. See map, pp. 460, 461. These stations include: seven gorges in central New York; six swamps in the central and western part of the state; four hilltops in the same area; six mountain stations, including three of the higher peaks and a pass in the Adirondack Mountains, one peak in the Catskill Mountains and one in the Shawangunk Mountains; Chautauqua Lake in the extreme western part of the state; Montauk Point on the east end of Long Island.

The stations represent the major physiographic regions and the principal watersheds of the state. The extremes in altitude are represented by Montauk Point at sea-level and the upper slopes of Mount Marcy which extend to its summit, 5344 feet above sea-level.

Sixty-three host species of trees and a few shrubs were chosen for study. These species were selected to include the common native trees of the state, a few introduced species, species representative of special habitats, and others intended to include representatives of a wider range of plant families. Not all hosts were studied or even represented at each of the 25 stations; a few, mostly those occurring but rarely in New York, were studied at only one or a few stations; many were studied at a number of stations. The species of hosts and the stations at which each was studied are recorded in Table 1.

Most of the stations were visited and studied a number of times but most of the collections were made during the spring and early summer. At each station several to many individuals of each host were examined for epiphytes. Since most of the epiphyte species required examination under magnification for determination, collections were made for laboratory study. For the determination of species the following references have been most helpful: lichens, Fink (1935); liverworts, Frye and Clark (1937-1946), Steere (1940); mosses, Grout (1924, 1928-1940), Evans and Nichols (1908). Representative sam-

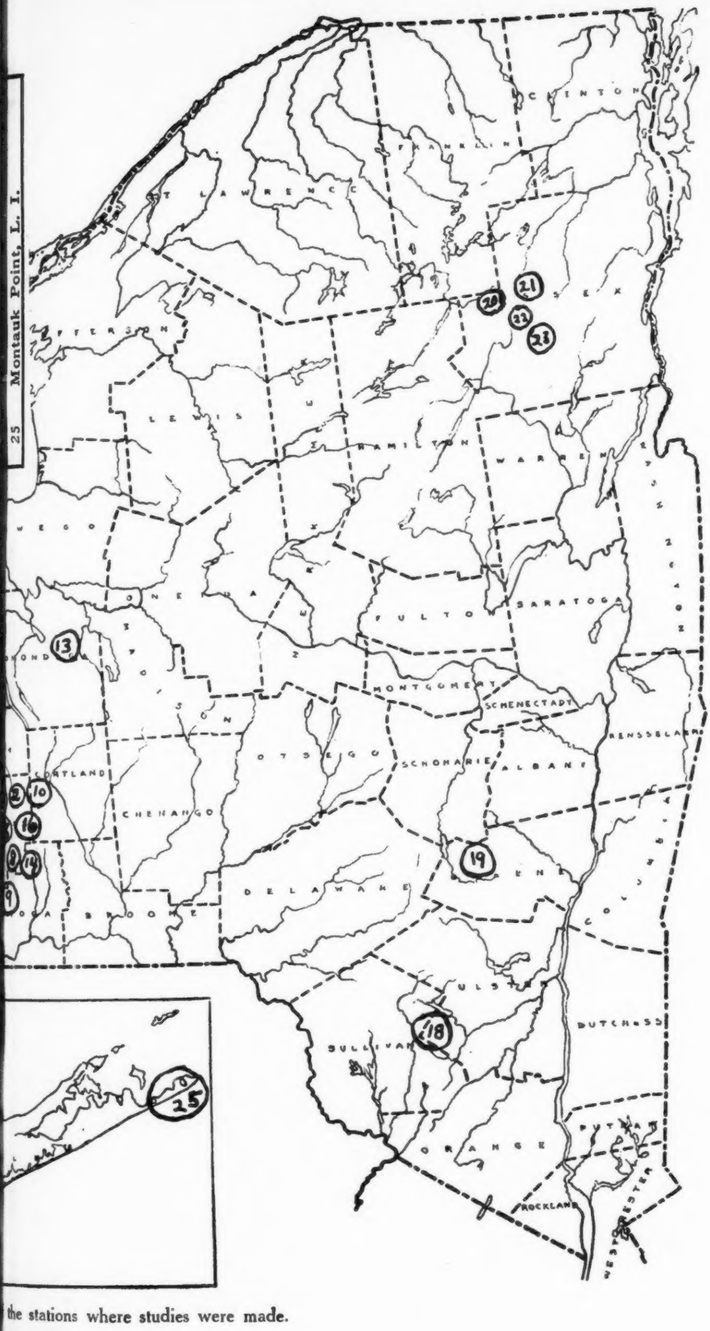
GORGES	1	Six Mile
	2	Fall Creek
	3	Buttermilk
	4	Coy Glen
	5	Enfield
	6	Big Gully
	7	Cayuta Lake Outlet
SWAMPS	8	Michigan Hollow
	9	Headwaters
	10	McLean Bogs
	11	Junius
	12	Bergen
	13	Jamesville
HILLS	14	South Hill
	15	Connecticut Hill
	16	Slaterville
	17	Rock City
MOUNTAINS	18	Shawangunk Mts.
	19	Catskill Mts.
	20	Indian Pass
	21	Mt. MacIntyre
	22	Mt. Colden
	25	Montauk Point, L. I.



Map of New York state showing locat[illegible] the sta[illegible]

NTAINS

21	Mt. MacIntyre
22	Mt. Colden
25	Montauk Point, L. I.



ing locati the stations where studies were made.

ples were preserved as herbarium specimens in the herbarium of Cornell University.

The distribution data obtained in this survey are recorded for convenience of reference as follows:

1. An annotated list of epiphytes in which are summarized, for each species, its preferences for hosts, general distribution by stations and the zone or part of the host (crown, crown base, trunk, trunk base or stump) on which it occurs most frequently.

2. A host index, including a complete list of epiphytic lichens, liverworts and mosses observed on each of the 63 hosts studied. The data pertaining to the hosts and distribution of the few algae and ferns observed as epiphytes are not summarized or included in the host index but may be found in the annotated list.

Annotated List of Epiphytes showing their Distribution by Hosts, Stations and Zones

LICHENS

1. ALECTORIA CHALYBEIFORMIS (L.) Rohling
   Hosts.—5, all conifers.
   Stations.—5, swamps and upper Enfield gorge.
   Zone.—Crown and trunk.

2. ALECTORIA JUBATA (L.) Ach.
   Hosts.—5, common on *Abies balsamea* and *Picea rubra:* infrequent on *Betula* and *Sorbus.*
   Stations.—3, all on the higher Adirondack peaks.
   Zone.—Crown to trunk.

3. ANAPTYCHIA AQUILA var. DETONSA (E. Fries) Tuck.
   Hosts.—1, found only on *Acer saccharum.*
   Stations.—1, Hunter Mountain in the Catskills.
   Zone.—Trunk.

4. ARTHOTHELIUM SPECTABILE Mass.
   Hosts.—1, found only on *Acer saccharum.*
   Stations.—Six Mile Gorge.
   Zone.—Trunk.

5. BUELLIA PARASEMA (Ach.) DeNot.
   Hosts.—21, mostly hardwoods with smooth bark: rare on *Tsuga* and *Abies.*
   Stations.—11, widespread but common at Montauk and rare in the Adirondacks.
   Zone.—Trunk with smooth bark.

6. CETRARIA AURESCENS Tuck.
   Hosts.—5, *Picea mariana, Larix laricina, Populus* and *Ulmus.*
   Stations.—4, Montauk, McLean (Woodwardia bog) and rare in the gorges.
   Zone.—Trunk and crown base.

7. CETRARIA CILIARIS Ach.
   Hosts.—mostly (7) conifers and on a few hardwoods only in the Adirondacks and Catskills.
   Stations.—12, common, mostly on the higher mountain peaks; local in the lowland swamps.
   Zone.—Crown, often on the smaller branches.

8. CETRARIA JUNIPERINA (L.) Ach.
Hosts.—7, mostly conifers; *Betula, Alnus crispa* and *Acer saccharum.*
Stations.—5, all on the higher Adirondacks and Catskills.
Zone.—Crown and crown base; mostly on small branches.

9. CLADONIA PYXIDATA (L.) Hoffm.
Hosts.—59, this includes all but 4 of the hosts examined, *Carya alba, Alnus crispa, Rhus vernix* and *Nyssa sylvatica.* The failure to find it on these hosts is probably accounted for by the few stations in which they were available.
Stations.—25, this lichen has a widespread distribution but is most abundant in the gorges.
Zone.—Stumps and lower trunks; rarely in moist protected cracks of bark on the lower crown.

10. CLADONIA RANGIFERINA (L.) Web.
Hosts.—5, *Pinus strobus, Picea rubra, Abies balsamea, Betula lutea* and *B. papyrifera.*
Stations.—2, Indian Pass and Headwaters Swamp.
Zone.—Stumps. This species is rare as an epiphyte even in the regions where it is common on the soil and rocks.

11. EVERNIA FURFURACEA (L.) Mann.
Hosts.—6, mostly conifers, *Betula* and *Sorbus.*
Stations.—6, in the Adirondacks, Catskills and Shawangunk Mountains.
Zone.—Crown and trunk.

12. EVERNIA PRUNASTRI (L.) Ach.
Hosts.—17; the most common are conifers.
Stations.—13; mostly in the Adirondacks and Catskills; local in swamps.
Zone.—Upper trunk and crown base.

13. GRAPHIS SCRIPTA (L.) Ach.
Hosts.—26, all hardwoods with smooth areas on bark.
Stations.—22, widespread from Montauk to Mt. Marcy and to Chautauqua Lake.
Zone.—Trunk.

14. LECANORA PALLIDA (Schreb.) Rabh.
Hosts.—15, mostly hardwoods with smooth bark.
Stations.—3, common at Montauk, rare in the Catskills and Adirondacks.
Zone.—Trunk.

15. LECANORA SUBFUSCA (L.) Ach.
Hosts.—12, hardwoods with rather smooth bark and *Abies balsamea.*
Stations.—10, widespread in the Adirondacks, Catskills and Shawangunk Mountains, and in the gorges.
Zone.—Trunk.

16. LECIDEA VERNALIS (L.) Ach.
Hosts.—9, mostly common hardwoods.
Stations.—8, widespread; infrequent in the mountains except the Shawangunks.
Zone.—Trunk.

17. LEPTOGIUM TREMELLOIDES (L.) S. F. Gray
Hosts.—9, hardwoods of which *Juglans cinerea* seems to be the most frequent, and at one station *Juniperus virginiana.*
Stations.—10, mostly in ravines and swamps.
Zone.—Protected stump and lower part of trunk where bark is very moist.

18. MYCOBLASTUS SANGUINARIUS var. ALPINUS (E. Fries) Stein.
Hosts.—17, hardwoods and in the mountains also on conifers.
Stations.—12, in the gorges and mountains.
Zone.—Mostly on lower trunk and stump; on rough irregular bark.

19. PARMELIA CAPERATA (L.) Ach.
Hosts.—52, common on most trees especially where they are not crowded.
Stations.—25, most abundant on scattered trees in swamps and protected places.
Zone.—Upper trunk and crown base, sometimes in the crown.

20. PARMELIA CETRATA Ach.
Hosts.—8 conifers and harwoods.
Stations.—5, limited to the Adirondacks and Catskills.
Zone.—Trunk and rarely crown base.

21. PARMELIA OLIVACEA (L.) Ach.
Hosts.—47, common except on a few of the rarer hosts.
Stations.—24, all but the Shawangunk Mountains where it may have been overlooked.
Zone.—Trunk.

22. PARMELIA PERFORATA (Wulf.) Ach.
Hosts.—2, *Juglans cinerea* and *Acer saccharum*.
Stations.—4, Cayuta Lake Outlet, the Catskills, and Adirondacks.
Zone.—Trunk.

23. PARMELIA PERLATA (L.) Ach.
Hosts.—8, common hardwoods.
Stations.—7, mostly swamps; Catskills and Rock City.
Zone.—Trunk.

24. PARMELIA PERTUSA (Schrank.) Schaer.
Hosts.—10, mostly conifers.
Stations.—8, mostly in swamps; at Rock City on hardwoods.
Zone.—Trunk and crown base.

25. PARMELIA PHYSODES (L.) Ach.
Hosts.—39, common on many hardwoods; abundant on conifers in the Adirondacks and Catskills and in wet swamps and gorges.
Stations.—22, not found on Connecticut Hill, in Buttermilk Gorge or at Montauk Point.
Zone.—Crown, common on smaller branches especially on conifers, crown base and less frequently on trunks.

26. PARMELIA RUDECTA Ach.
Hosts.—44, this includes nearly all but the rarer species examined.
Stations.—20, widespread but not found in the Adirondacks.
Zone.—Trunk and crown base.

27. PELTIGERA CANINA (L.) Willd.
Hosts.—15, hardwoods.
Stations.—13, widespread but less common on higher mountains.
Zone.—Stump, rarely trunk.

28. PERTUSARIA MULTIPUNCTA (Turw.) Nyl.
Hosts.—7. conifers and hardwoods; mostly on smooth bark.
Stations.—7, Montauk, Adirondacks and rare in gorges.
Zone.—Trunk.

29. PHYSCIA ASTROIDEA (Clem.) Nyl.
Hosts.—30, mostly hardwoods; very common on *Ulmus americana*.

Stations.—16, widespread but not found in mountains.
Zone.—Upper trunk and crown base.

30. PHYSCIA ENDOCHRYSEA (Hampe) Nyl.
Hosts.—41, hardwoods and *Juniperus* and *Thuja*.
Stations.—24, widespread but infrequent in the higher Adirondacks; most common about gorges.
Zone.—Trunk and crown base.

31. PHYSCIA STELLARIS (L.) Nyl.
Hosts.—11, hardwoods and *Pinus rigida*, on rough bark.
Stations.—10, mostly in swamps and gorges; Chautauqua Lake; not found in the mountains or on Montauk Point.
Zone.—Trunk and base of crown.

32. PHYSCIA TRIBACIA (Ach.) Nyl.
Hosts.—2, *Populus balsamifera* and *Quercus borealis*.
Stations.—1, Montauk Point.
Zone.—Lower trunk.

33. PYRENULA NITIDA (Weig.) Ach.
Hosts.—11, only hardwoods.
Stations.—12, widespread; not found in the Adirondacks.
Zone.—Trunk and crown base.

34. RAMALINA CALICARIS (L.) Nyl.
Hosts.—7, hardwoods; most commonly found on *Ulmus americana*.
Stations.—7, in swamps and gorges.
Zone.—Trunk.

35. RAMALINA POLLINARIA (Westr.) Ach.
Hosts.—3, *Ulmus americana*, *Liriodendron tulipifera* and *Sorbus americana*.
Stations.—4, Coy Glen, Michigan Hollow, McLean Bogs and Mt. Marcy.
Zone.—Trunk.

36. STICTA PULMONARIA (L.) Bir.
Hosts.—8, mostly hardwoods, infrequent.
Stations.—9, mostly in mountains and swamps.
Zone.—Stump and lower trunk.

37. USNEA BARBATA (L.) Wigg.
Hosts.—8, mostly on conifers; infrequent on hardwoods except on *Betula* and *Sorbus* on the higher Adirondacks.
Stations.—7, common on Adirondacks rare in Coy Glen, Headwaters Swamp and McLean Bogs.
Zone.—Upper trunk and crown.

ALGAE

38. APHANATHECE sp.
Hosts.—4, hardwoods.
Stations.—2, Headwaters Swamp and Cayuta Lake Outlet.
Zone.—Stump, in moist shaded places.

39. PROTOCOCCUS VIRIDIS Ag.
Hosts.—61, all species examined except *Carya alba* and *Alnus crispa*. The failure to find it on these is probably because only a few trees were available for examination.
Stations.—23, common on moist or shaded trees at all stations.
Zone.—Stump and lower trunk.

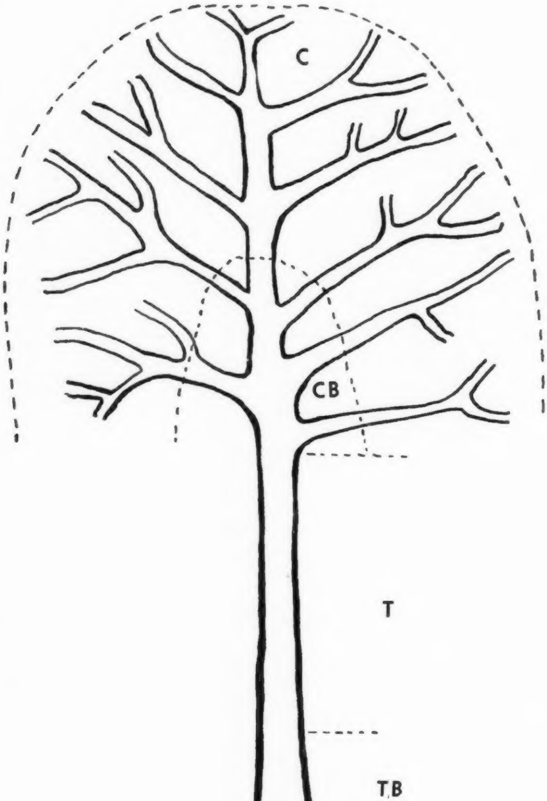


Figure 1.—Diagram showing relative position of zones used in designating the location of epiphytes on a tree. S—stump; TB—trunk base; T—trunk; CB—crown base; C—crown.

40. TRENTEPOHLIA AUREA (L.) Mart.
Hosts.—20, all hardwoods.
Stations.—6, in gorges and Indian Pass, moist situations mostly near streams.
Zone.—Stump and trunk.

HEPATICAE

41. BAZZANIA TRILOBATA (L.) S. F. Gray
Hosts.—11, mostly conifers and *Betula*. The most common host is *Tsuga canadensis*.
Stations.—15, widespread.
Zone.—Stump, in moist protected situations.

42. CALYPOGEIA NEESIANA (Massal et Corest.) K. Mull.
Hosts.—1, *Acer rubrum*.
Stations.—1, Headwaters Swamp.
Zone.—Stump.

43. CEPHALOZIA MEDIA Lindb.
Hosts.—4, *Abies balsamea, Populus tremuloides, Acer rubrum*, and *Fraxinus americana*.
Stations.—2, Headwaters Swamp for the first 3 hosts and Shawangunk Mountains for the last host.
Zone.—Stump and lower trunk.

44. CHILOSCYPHUS POLYANTHUS (L.) Corda
Hosts.—1, *Acer rubrum*.
Stations.—1, McLean Bogs.
Zone.—Stump, in very wet area.

45. COLOLEJEUNEA BIDDLECOMIAE (Aust.) Evans. Often found among other liverworts.
Hosts.—14, hardwoods and *Thuja occidentalis*.
Stations.—11, gorges and swamps; not seen in the mountains.
Zone.—Lower trunk and stump.

46. FRULLANIA ASAGRAYANA Mont. Usually found with *Frullania eboracensis*.
Hosts.—6, conifers and hardwoods; most specimens were found on *Betula lutea*.
Stations.—6, mostly in the mountains.
Zone.—Trunk.

47. FRULLANIA EBORACENSIS Gottsche
Hosts.—43, very common on most species except conifers.
Stations.—24, widespread but less common in the Adirondacks.
Zone.—Trunk and crown base, chiefly on smooth bark or on flat surfaces of ridges of rough bark.

48. JAMESONIELLA AUTUMNALIS (DC.) Steph.
Hosts.—17, hardwoods and conifers.
Stations.—13, mostly in the Adirondacks and Rock City.
Zone.—Stump and lower trunk, usually growing among mosses and other liverworts.

49. LEJEUNIA CAVIFOLIA (Ehr.) Lindb.
Hosts.—1, *Carya glabra*.
Stations.—1, Six Mile Gorge.
Zone.—Stump and lower trunk. This is a minute species easily overlooked which may, in part, explain its apparent rareness.

50. LEPIDOZIA REPTANS (L.) Dum.
Hosts.—3, *Picea rubra, Thuja occidentalis* and *Betula papyrifera*.

TABLE 1.—Distribution of hosts at each station.*

	Locality	GORGES							SWAMPS						HILLS				MOUNTAINS								
	Species	1 Six Mile	2 Fall Creek	3 Buttermilk	4 Coy Glen	5 Enfield	6 Big Gully	7 Cayuta Lake Outlet	8 Michigan Hollow	9 Headwaters	10 McLean Bogs	11 Junius	12 Bergen	13 Jamesville	14 South Hill	15 Connecticut Hill	16 Slaterville	17 Rock City	18 Shawangunk Mts.	19 Catskill Mts.	20 Indian Pass	21 Mt. MacIntyre	22 Mt. Colden	23 Mt. Marcy	24 Chautauqua Lake	25 Montauk Point, L. I.	Total Stations collected
1	Pinus resinosa	o	+	+	+	+	−	o	o	−	−	−	−	−	o	+	−	−	−	−	−	−	−	−	−	−	5
2	Pinus rigida	o	+	+	+	+	−	−	−	o	−	+	−	−	+	o	−	−	+	−	−	−	−	−	−	+	8
3	Pinus strobus	+	+	+	+	+	+	+	+	+	+	+	+	o	+	+	+	+	+	+	o	o	o	o	+	o	19
4	Picea mariana	−	−	−	−	−	−	−	−	−	−	+	−	−	−	−	−	−	−	−	o	o	o	o	−	−	1
5	Picea rubra	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	+	+	+	+	+	−	−	5
6	Abies balsamea	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	+	+	+	+	+	−	−	5
7	Larix laricina	−	−	−	−	−	−	−	+	+	−	+	+	−	−	−	−	−	−	−	o	o	+	o	−	−	5
8	Tsuga canadensis	+	+	+	+	+	+	+	+	+	+	o	+	+	o	o	+	+	o	+	o	−	−	−	+	−	16
9	Thuja occidentalis	−	−	−	−	−	−	−	−	−	−	+	+	+	−	−	−	−	−	−	+	o	o	+	−	−	5
10	Juniperus virginiana	+	o	+	+	+	+	−	+	−	−	o	o	o	o	o	o	−	o	o	−	−	−	−	−	+	7
11	Populus balsamifera	+	+	+	o	+	o	−	−	−	o	o	o	+	−	−	o	−	o	o	−	−	−	−	o	+	6
12	Populus tremuloides	+	+	+	+	+	+	+	+	+	+	o	+	+	+	+	o	+	o	+	o	o	o	o	+	o	17
13	Populus grandidentata	+	+	+	+	+	+	+	+	o	+	+	+	o	o	+	o	+	o	+	o	o	o	o	+	o	15
14	Myrica carolinensis	−	−	−	−	−	−	−	−	+	−	+	+	−	−	−	−	−	−	−	−	−	−	−	−	+	4
15	Juglans cinerea	+	+	+	+	+	+	+	+	+	+	+	+	+	o	o	+	−	+	+	−	−	−	−	+	o	17
16	Juglans nigra	−	+	+	−	o	−	+	−	+	−	−	−	−	−	o	−	−	−	−	−	−	−	−	+	−	5
17	Carya alba	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	+	1
18	Carya cordiformis	+	+	+	+	+	+	o	o	o	o	+	+	+	+	o	o	−	o	o	−	−	−	−	o	o	10
19	Carya glabra	+	+	+	+	+	+	o	o	o	−	+	−	+	+	o	o	−	o	o	−	−	−	−	o	o	9
20	Carya ovata	+	+	+	+	+	+	+	o	o	o	+	+	o	+	o	o	−	o	o	−	−	−	−	+	o	[illegible]
[25]	Betula papyrifera	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	8
26	Betula populifolia	−	−	−	−	−	−	−	−	−	−	−	o	+	−	−	−	−	+	−	−	−	−	−	−	o	2
27	Alnus crispa	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	+	+	+	o	−	−	3
28	Alnus incana	o	o	o	o	o	−	+	+	+	+	o	o	o	−	+	o	−	−	o	−	−	−	−	−	o	5

17	Carya alba	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	+	1
18	Carya cordiformis	+	+	+	+	+	+	O	O	O	O	+	+	+	+	O	O	—	O	O	—	—	—	—	O	O	10
19	Carya glabra	+	+	+	+	+	+	O	O	O	—	+	—	+	+	O	O	—	O	O	—	—	—	—	O	O	10
20	Carya ovata	+	+	+	+	+	+	O	O	O	—	+	—	+	+	O	O	—	O	O	—	—	—	—	O	O	9
25	Betula papyrifera	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	6
26	Betula populifolia	—	—	—	—	—	—	—	—	—	—	—	O	+	—	—	—	—	+	—	—	—	—	—	—	O	2
27	Alnus crispa	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	+	+	+	O	—	—	3
28	Alnus incana	O	O	O	O	O	—	+	+	+	+	O	O	O	—	+	O	—	—	O	—	—	—	—	—	O	5
29	Fagus grandifolia	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	O	+	O	O	+	+	22
30	Quercus alba	+	+	+	+	+	+	+	O	+	O	+	O	O	+	+	+	+	+	+	—	—	—	—	+	+	17
31	Quercus bicolor	—	O	—	—	—	—	O	O	O	+	—	+	—	+	—	—	—	—	—	—	—	—	—	—	O	3
32	Quercus borealis	+	+	+	+	+	+	+	+	O	O	+	O	+	+	+	O	+	+	+	—	—	—	—	+	+	17
33	Quercus coccinea	O	O	+	+	+	O	O	O	—	—	+	—	O	+	+	O	—	O	O	—	—	—	—	—	+	7
34	Quercus montana	O	O	+	+	O	O	+	O	—	—	O	—	—	+	+	O	+	+	O	—	—	—	—	+	O	8
35	Quercus stellata	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	+	1
36	Quercus velutina	+	+	+	+	+	+	O	O	—	—	O	—	O	+	O	O	—	O	O	—	—	—	—	O	+	8
37	Ulmus americana	+	+	+	+	+	+	+	+	+	+	+	+	+	O	+	+	—	O	+	—	—	—	—	+	O	17
38	Ulmus fulva	O	O	O	+	+	+	O	O	O	O	O	O	+	O	O	O	—	O	+	—	—	—	—	—	O	5
39	Magnolia acuminata	+	O	+	+	+	O	+	+	+	O	O	O	O	O	O	O	+	O	O	—	—	—	—	+	O	9
40	Liriodendron tulipifera	+	+	+	+	+	+	O	O	O	O	+	—	+	—	—	O	—	—	O	—	—	—	—	+	O	9
41	Sassafras officinale	O	+	O	+	O	O	+	O	O	—	+	—	—	—	+	O	O	O	O	—	—	—	—	—	+	6
42	Platanus occidentalis	+	+	+	O	+	+	—	—	—	—	O	+	+	—	—	O	—	—	—	—	—	—	—	+	O	8
43	Amelanchier canadensis	+	O	+	+	+	+	+	+	+	+	O	+	+	O	+	O	O	O	O	—	—	—	—	+	O	13
44	Amelanchier oblongifolia	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	+	1
45	Malus pumila	+	O	O	O	O	O	+	+	+	O	O	+	+	—	+	—	+	—	—	—	—	—	—	+	—	9
46	Prunus serotina	+	+	+	+	+	+	+	+	+	+	+	+	+	O	+	+	+	+	+	+	+	O	O	+	+	22
47	Prunus virginiana	+	+	+	+	+	+	+	O	O	+	+	+	O	O	O	O	O	O	O	O	O	O	O	O	O	10
48	Pyrus communis	O	O	O	O	O	O	O	O	O	—	O	—	—	—	+	—	—	—	—	—	—	—	—	—	—	1
49	Sorbus americana	—	—	—	—	—	—	—	O	—	+	—	—	—	—	—	—	+	O	+	+	+	+	+	+	O	8
50	Robinia Pseudo-acacia	+	+	O	O	O	O	—	O	O	O	O	O	O	O	O	O	O	—	—	—	—	—	—	O	O	2
51	Rhus vernix	—	—	—	—	—	—	—	+	+	+	+	O	O	—	—	—	—	—	—	—	—	—	—	—	+	5
52	Acer pennsylvanicum	O	O	O	O	O	O	O	O	O	O	O	—	O	O	O	O	+	O	+	+	+	+	+	+	O	7
53	Acer rubrum	+	+	+	+	+	O	+	+	+	+	+	+	+	+	+	+	+	+	+	O	O	O	O	+	+	20
54	Acer saccharum	+	+	+	+	+	+	+	+	O	+	+	+	+	O	+	+	+	+	+	+	+	O	O	+	O	20
55	Tilia americana	+	+	+	+	+	+	+	+	+	+	+	+	+	O	+	+	—	+	O	—	—	—	—	+	O	17
56	Nyssa sylvatica	—	O	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	+	+	2
57	Cornus florida	+	+	+	+	+	O	+	O	—	—	+	O	O	O	+	O	O	O	O	—	—	—	—	+	+	10
58	Rhododendron maximum	—	—	—	—	—	—	—	+	—	—	—	—	—	—	—	—	—	—	O	—	—	—	—	—	—	1
59	Kalmia latifolia	—	—	—	—	O	—	+	—	+	—	—	—	—	—	—	—	+	+	O	—	—	—	—	—	+	5
60	Fraxinus americana	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	—	—	—	—	+	+	21
61	Fraxinus nigra	—	+	+	+	+	+	O	+	+	+	+	+	+	—	—	O	—	—	O	O	—	—	—	+	O	12
62	Fraxinus pennsylvanica	—	—	—	—	—	—	+	—	—	—	—	+	O	—	—	—	—	—	—	—	—	—	—	+	O	3
63	Cephalanthus occidentalis	—	—	—	—	—	—	+	—	—	—	+	+	—	+	—	—	—	—	—	—	—	—	—	+	+	6

* Key to symbols: + = Host from which specimens were taken; — = host notseen; O = host from which no specimens were taken.

Stations.—3, Catskills, Mt. Marcy (Betula), Bergen Swamp (Thuja).
Zone.—Stump and lower trunk.

51. LOPHOCOLEA HETEROPHYLLA (Schrad.) Dum.
Hosts.—44, its apparent absence on some of the hosts may be due to the small number of specimens available for examination.
Stations.—23, common except on the higher Adirondack Peaks.
Zone.—Stump and trunk, rarely base of crown.

52. LOPHOCOLEA MINOR Nees
Hosts.—2, *Betula papyrifera, Acer rubrum.*
Stations.—2, Shawangunk and Catskill Mountains.
Zone.—Lower trunk.

53. LOPHOZIA ATTENUATA (Mart.) Dum.
Hosts.—3, *Picea rubra, Abies balsamea* and *Betula papyrifera.*
Stations.—4, Adirondack Mountains.
Zone.—Lower trunk; among mosses and larger liverworts.

54. LOPHOZIA VENTRICOSA (Dicks.) Dum.
Hosts.—8, most abundant on conifers.
Stations.—5, Adirondacks, Catskills and Shawangunk Mountains.
Zone.—Lower trunk and stump; mostly among mosses.

55. NOWELLIA CURVIFOLIA (Dicks.) Mitten
Hosts.—2, *Picea rubra* and *Thuja occidentalis.*
Stations.—1, Mount Marcy.
Zone.—Lower trunk.

56. PORELLA PINNATA L.
Hosts.—1, *Acer rubrum.*
Stations.—2, Cayuta Lake Outlet and Bergen Swamp.
Zone.—Lower trunk and stump. In very damp places.

57. PORELLA PLATYPHYLLA (L.) Lindb.
Hosts.—1, *Ulmus americana.*
Stations.—1, Cayuta Lake Outlet.
Zone.—Stump, very wet swamp.

58. PORELLA PLATYPHYLLOIDEA (Schwein.) Lindb.
Hosts.—25, mostly hardwoods.
Stations.—20, widespread mostly in gorges and swamps; rare in the mountains; not seen at Rock City, Chautauqua Lake or Montauk Point.
Zone.—Mostly trunk and stump, infrequently base of crown.

59. PLAGIOCHILA ASPLENIOIDES (L.) Dum.
Hosts.—1, *Ulmus americana.*
Stations.—1, Bergen Swamp.
Zone.—Stump and lower trunk.

60. PTILIDIUM PULCHERRIMUM (Web.) Hampe
Hosts.—39, conifers and hardwoods; most common on *Betula lutea, Prunus serotina* and *Acer rubrum.*
Stations.—22, widespread except at Big Gully, Fall Creek and Montauk Point.
Zone.—Trunk, base of crown and stump.

61. RADULA COMPLANATA (L.) Dum.
Hosts.—37, mostly hardwoods, rare on conifers.
Stations.—19, common in gorges and swamps; rare in the Adirondacks, not seen in Junius Swamp, Shawungunk Mountains or on Montauk Point.
Zone.—Lower trunk and stump.

62. RICCARDIA LATIFRONS Lindb.
Hosts.—4, *Thuja occidentalis*, *Betula lutea*, *Prunus serotina* and *Acer saccharum.*
Stations.—4, Michigan Hollow, Bergen Swamp, Cayuta Lake Outlet and Coy Glen.
Zone.—Lower trunk and stump, where very wet.

63. RICCARDIA PINGUIS (L.) S. F. Gray
Hosts.—2, *Thuja occidentalis*, *Quercus borealis.*
Stations.—2, Bergen Swamp, Cayuta Lake Outlet.
Zone.—Stump, in very moist places.

64. SCAPANIA NEMEROSA (L.) Dum.
Hosts.—1, *Thuja occidentalis.*
Stations.—1, Mt. Marcy, lower slopes.
Zone.—Stump and lower trunk.

65. TRICHOCOLEA TOMENTELLA (Ehrh.) Dum.
Hosts.—1, *Ulmus americana.*
Stations.—1, Bergen Swamp.
Zone.—Stump, in moist, shaded situations.

MOSSES

66. AMBLYSTEGIUM SERPENS Hedw.
Hosts.—23, mostly hardwoods.
Stations.—14, local in gorges and swamps; not found on the mountains, Montauk Point or Rock City.
Zone.—Stump and lower trunk.

67. AMBLYSTEGIUM VARIUM (Hedw.) Lindb.
Hosts.—2, *Quercus alba* and *Fraxinus pennsylvanica.*
Stations.—2, South Hill and Bergen Swamp.
Zone.—Stump and lower trunk.

68. ANOMODON ATTENUATUS (Schreb.) Hueb.
Hosts.—33, mostly hardwoods.
Stations.—19, most common in gorges and swamps; not found on the Adirondacks or Montauk Point.
Zone.—On stump and lower trunk.

69. ANOMODON ROSTRATUS (Hedw.) Schimp.
Hosts.—21, mostly hardwoods.
Stations.—15, chiefly in gorges and marshes; not found on the Adirondacks, Catskills or Montauk Point.
Zone.—Stump and trunk.

70. ANOMODON RUGELII (C. M.) Keissl.
Hosts.—5, on hardwoods.
Stations.—5, mostly on lower mountains; rare in Buttermilk Gorge.
Zone.—Stump and lower trunk.

71. BRACHYTHECIUM OXYCLADON (Brid.) J. and S.
Hosts.—38, chiefly hardwoods.
Stations.—20, widespread except on the Adirondacks and Montauk Point.
Zone.—Stump and trunk, rarely crown base.

72. BRACHYTHECIUM STARKEI (Brid.) Br. and Sch.
Hosts.—5, *Abies balsamea*, *Betula lutea*, *Fagus grandifolia*, *Sorbus americana*, and *Acer saccharum.*
Stations.—4, all on the Adirondacks.
Zone.—Stump and trunk.

73. BROTHERELLA RECURVANS (Michx.) Fleisch.
Hosts.—9, most commonly observed on conifers and *Betula*.
Stations.—10, chiefly on the Adirondacks.
Zone.—Stump and lower trunk.

74. CAMPYLIUM CHRYSOPHYLLUM (Brid.) Bryhn.
Hosts.—27, mostly hardwoods.
Stations.—13, most common in swamps, frequent in gorges, not observed in the mountains.
Zone.—Stump and lower trunk.

75. CAMPYLIUM HISPIDULUM (Brid.) Mitten
Hosts.—1, *Populus tremuloides*.
Stations.—1, Mount McIntyre.
Zone.—Stump and lower trunk.

76. CLIMACIUM AMERICANUM Brid.
Hosts.—1, *Fraxinus nigra*.
Stations.—1, McLean Bogs.
Zone.—Stump, in wet situations.

77. CLIMACIUM KINDBERGII (R. and C.) Grout
Hosts.—1, *Cephalanthus occidentalis*.
Stations.—1, Montauk Point, in wet bog.
Zone.—Stump and lower trunk.

78. DICRANUM FLAGELLARE Hedw.
Hosts.—49, both conifers and hardwoods.
Stations.—21, widespread except on the Adirondacks.
Zone.—Stump and lower trunk.

79. DICRANUM FULVUM Hook.
Hosts.—23, mostly hardwoods.
Stations.—16, widespread except on the Adirondacks and Montauk Point.
Zone.—Stumps.

80. DICRANUM FUSCESCENS Turn.
Hosts.—8, conifers and hardwoods.
Stations.—6, in the mountains.
Zone.—Stump and lower trunk base.

81. DICRANUM LONGIFOLIUM Ehrh.
Hosts.—10, conifers and hardwoods.
Stations.—5, found only in the Adirondacks and Catskills.
Zone.—Stump and lower trunk.

82. DICRANUM MONTANUM Hedw.
Hosts.—15, chiefly conifers.
Stations.—14, chiefly in gorges and swamps.
Zone.—Stump and lower trunk.

83. DREPANOCLADUS UNCINATUS (Hedw.) Warnst.
Hosts.—3, *Betula lutea*, *Acer pennsylvanicum* and *Acer rubrum*.
Stations.—4, in the Adirondacks and in Michigan Hollow Swamp.
Zone.—On stump.

84. FISSIDENS ADIANTOIDES (L.) Hedw.
Hosts.—5, *Thuja occidentalis* and hardwoods.
Stations.—2, Bergen Swamp and Jamesville.
Zone.—Stump and lower trunk.

85. HYPNUM CRISTA-CASTRENSIS L.
Hosts.—1, *Betula papyrifera.*
Stations.—2, Indian Pass and Mount Colden.
Zone.—Stump and lower trunk.

86. HYPNUM CUPRESSIFORME L.
Hosts.—2, *Thuja occidentalis, Betula lutea.*
Stations.—2, Catskills and Mount Marcy.
Zone.—Stump and lower trunk.

87. HYPNUM HALDANIANUM Grev.
Hosts.—29, chiefly hardwoods.
Stations.—17, widespread in gorges and swamps.
Zone.—Stump and trunk.

88. HYPNUM IMPONENS Hedw.
Hosts.—32, conifers and hardwoods.
Stations.—22, widespread, but less common in the mountains.
Zone.—Trunk and stump.

89. HYPNUM PALLESCENS (Hedw.) Br. and Sch.
Hosts.—11, conifers and hardwoods.
Stations.—4, all in the Adirondacks.
Zone.—Stump and trunk.

90. HYPNUM REPTILE Michx.
Hosts.—33, hardwoods and conifers especially *Tsuga canadensis.*
Stations.—23, widespread but not found at Montauk Point and Junius.
Zone.—Stump and lower trunk.

91. HYPNUM SCHREBERI Willd.
Hosts.—4, chiefly *Betula lutea* and *Abies balsamea* also on *Betula papyrifera* and *Picea rubra.*
Stations.—4, Adirondacks and Catskills.
Zone.—Stump and lower trunk.

92. LEPTODICTYUM RIPARIUM (Hedw.) Warnst.
Hosts.—3, *Acer rubrum, Fraxinus pennsylvanica,* and *Cephalanthus occidentalis.*
Stations.—2, Cayuta Lake Outlet and Bergen Swamp.
Zone.—Stump, in low wet areas where it is inundated part of the year.

93. LEUCODON SCIUROIDES (L.) Schwaegr.
Hosts.—8, all hardwoods.
Stations.—7, mostly in swamps and gorges, also in Indian Pass.
Zone.—Trunk, mostly on the exposed dry upper part.

94. NECKERA PENNATA (L.) Hedw.
Hosts.—6, hardwoods.
Stations.—9, most common in the Adirondacks.
Zone.—Trunk and stump.

95. ORTHOTRICHUM STRANGULATUM Sulliv.
Hosts.—12, hardwoods.
Stations.—10, widespread, but not found on the Adirondacks or on Montauk Point.
Zone.—Upper trunk and crown base.

96. PLAGIOTHECIUM DENTICULATUM (L.) Br. and Sch.
Hosts.—55, common on many hosts.

Stations.—25, widespread and common except on higher mountains.
Zone.—Stump and lower trunk.

97. PLAGIOTHECIUM STRIATELLUM (Brid.) Lindb.
Hosts.—16, hardwoods and conifers.
Stations.—5, on the Adirondacks and Montauk Point.
Zone.—Stump and lower trunk.

98. PLATYGYRIUM REPENS (Brid.) Br. and Sch.
Hosts.—52, hardwoods and conifers.
Stations.—22, widespread except on the Adirondacks.
Zone.—Stump and lower trunk.

99. PTERIGYNANDRUM FILIFORME Hedw.
Hosts.—1, found only on *Acer saccharum.*
Stations.—1, Hunter Mountain in the Catskills.
Zone.—Stump.

100. PYLAISIA SELWYNII Kindb.
Hosts.—13, mostly hardwoods.
Stations.—10, widespread, mostly in swamps and gorges.
Zone.—Stump and lower trunk.

101. PYLAISIA VELUTINA Schimp.
Hosts.—12, hardwoods.
Stations.—11, widespread, mostly in gorges.
Zone.—Stump and trunk.

102. RHODOBRYUM ROSEUM (Weiss.) Limpr.
Hosts.—5, chiefly *Ulmus americana* and *Fraxinus nigra.*
Stations.—8, chiefly in swamps.
Zone.—Stump and rarely in cracks of bark on trunk.

103. THELIA ASPRELLA (Schimp.) Sulliv.
Hosts.—3, *Quercus alba, Carya glabra* and *Ulmus americana.*
Stations.—5, most common on South Hill.
Zone.—Stump.

104. THELIA HIRTELLA (Hedw.) Sulliv.
Hosts.—7, all hardwoods.
Stations.—1, Montauk Point.
Zone.—Stump.

105. THUIDIUM DELICATULUM (L.) Mitten
Hosts.—29, mostly hardwoods.
Stations.—19, widespread except on the Adirondacks.
Zone.—Stump and lower trunk.

106. THUIDIUM SCITUM (Beauv.) Aust.
Hosts.—2, *Juniperus virginiana* and *Acer saccharum.*
Stations.—2, Big Gully and Indian Pass.
Zone.—Lower trunk.

107. ULOTA LUDWIGII Brid.
Hosts.—1, *Acer pennsylvanicum.*
Stations.—1, Mount Marcy.
Zone.—Trunk.

108. ULOTA ULOPHYLLA (Ehrh.) Broth.
Hosts.—35, mostly hardwoods.
Stations.—22, widespread.
Zone.—Upper trunk.

FERNS

109. THELYPTERIS MARGINALIS (L.) Nieuwl.
On stump of *Acer rubrum*, Rock City.

110. THELYPTERIS SPINULOSA (D. F. Mull.) Nieuwl.
Hosts.—3, *Quercus borealis*, *Acer rubrum* and *Tilia americana*.
Stations.—4, gorges and swamps.
Zone.—Stump.

111. POLYPODIUM VIRGINIANUM L.
Hosts.—11, hardwoods and conifers.
Stations.—5, widespread, mostly in gorges.
Zone.—Stump

Host Index to Epiphytes

The 63 species of hosts examined, 10 gymnosperms and 53 angiosperms, are arranged in order by families. The species of lichens, liverworts and mosses observed are listed under each host. The total numbers of epiphytes on each host are summarized in Table 2, page 485.

1. PINUS RESINOSA.
Lichens.—Cladonia pyxidata.
Mosses.—Dicranum flagellare, D. fulvum, D. montanum, Platygyrium repens.

2. PINUS RIGIDA.
Lichens.—Alectoria chalybeiformis, Cetraria ciliaris, Cladonia pyxidata, Evernia furfuracea, E. prunastri, Parmelia caperata, P. olivacea, P. pertusa, P. rudecta, Physcia stellaris.
Mosses.—Brachythecium oxycladon, Dicranum flagellare.

3. PINUS STROBUS.
Lichens.—Alectoria chalybeiformis, Cetraria ciliaris, Cladonia pyxidata, C. rangiferina, Evernia prunastri, Parmelia caperata, P. olivacea, P. pertusa, P. physodes, P. rudecta, Physcia astroidea.
Liverworts.—Bazzania trilobata, Lophocolea heterophylla. Ptilidium pulcherrimum, Radula complanata.
Mosses.—Brachythecium oxycladon, Dicranum flagellare, D. montanum, Hypnum Haldanianum, H. imponens, H. reptile, Plagiothecium denticulatum, Platygyrium repens.

4. PICEA MARIANA.
Lichens.—Alectoria chalybeiformis, Cetraria aurescens, C. ciliaris, Cladonia pyxidata, Evernia prunastri, Mycoblastus sanguinarius, Parmelia caperata, P. olivacea, P. pertusa, P. physodes, Usnea barbata.

5. PICEA RUBRA.
Lichens.—Alectoria jubata, Cetraria ciliaris, C. juniperina, Cladonia pyxidata, C. rangiferina, Evernia furfuracea, E. prunastri, Parmelia caperata, P. cetrata, P. pertusa, P. physodes, P. rudecta, Usnea barbata.
Liverworts.—Bazzania trilobata, Jamesoniella autumnalis, Lepidozia reptans, Lophozia attenuata, L. ventricosa, Nowellia curvifolia, Ptilidium pulcherrimum.
Mosses.—Brotherella recurvans, Dicranum flagellare, D. fuscescens, D. longifolium, Hypnum pallescens, H. reptile, H. Schreberi, Plagiothecium denticulatum, P. striatellum, Platygyrium repens.

6. ABIES BALSAMEA.
Lichens.—Alectoria jubata, Buellia parasema, Cetraria ciliaris, C. juniperina, Cla-

donia pyxidata, C. rangiferina, Evernia furfuracea, E. prunastri, Lecanora pallida, L. subfusca, Mycoblastus sanguinarius, Parmelia caperata, P. cetrata, P. olivacea, P. physodes, Pertusaria multipuncta, Usnea barbata.

Liverworts.—Bazzania trilobata, Frullania Asagrayana, Jamesoniella autumnalis, Lophocolea heterophylla, Lophozia attenuata, L. ventricosa, Ptilidium pulcherrimum.

Mosses.—Brachythecium Starkei, Brotherella recurvans, Dicranum flagellare, D. fuscescens, D. longifolium, Hypnum imponens, H. pallescens, H. reptile, H. Schreberi, Plagiothecium denticulatum, P. striatellum.

7. LARIX LARICINA.

Lichens.—Alectoria chalybeiformis, Cetraria aurescens, C. ciliaris, C. juniperina, Cladonia pyxidata, Evernia prunastri, Mycoblastus sanguinarius, Parmelia caperata, P. cetrata, P. olivacea, P. pertusa, P. physodes, P. rudecta, Pertusaria multipuncta.

Liverworts.—Cephalozia media, Lophocolea heterophylla, Ptilidium pulcherrimum.

Mosses.—Anomodon rostratus, Dicranum flagellare, Dicranum montanum, Hypnum imponens, Plagiothecium, denticulatum, Platygyrium repens.

8. TSUGA CANADENSIS.

Lichens.—Alectoria chalybeiformis, Buellia parasema, Cetraria ciliaris, Cladonia pyxidata, Parmelia caperata, P. olivacea, P. pertusa, P. physodes, P. rudecta.

Liverworts.—Bazzania trilobata, Frullania eboracensis, Lophocolea heterophylla, Porella platyphylloidea, Ptilidium pulcherrimum, Radula complanata.

Mosses.—Anomodon attenuatus, A. rostratus, Brachythecium oxycladon, Campylium chrysophyllum, Dicranum flagellare, D. fulvum, D. montanum, Hypnum imponens, H. reptile, Plagiothecium denticulatum, Platygyrium repens, Pylaisia Selwynii, Thuidium delicatulum.

9. THUJA OCCIDENTALIS.

Lichens.—Cladonia pyxidata, Evernia prunastri, Parmelia caperata, P. cetrata, P. olivacea, P. pertusa, P. physodes, P. rudecta, Physcia endochrysea, Sticta pulmonaria.

Liverworts.—Bazzania trilobata, Cololejeunea Biddlecomiae, Frullania Asagrayana, F. eboracensis, Jamesoniella autumnalis, Lepidozia reptans, Lophocolea heterophylla, Lophozia ventricosa, Nowellia curvifolia, Porella platyphylloidea, Ptilidium pulcherrimum, Radula complanata, Riccardia latifrons, R. pinguis, Scapania nemerosa.

Mosses.—Amblystegium serpens, Anomodon attenuatus, Brotherella recurvans, Brachythecium oxycladon, Campylium chrysophyllum, Dicranum flagellare, D. fulvum, D. fuscescens, D. longifolium, Fissidens adiantoides, Hypnum cupressiforme, H. Haldanianum, H. pallescens, H. reptile, Plagiothecium denticulatum, Platygyrium repens, Pylaisia Selwynii, Thuidium delicatulum, Ulota ulophylla.

10. JUNIPERUS VIRGINIANA.

Lichens.—Cladonia pyxidata, Leptogium tremelloides, Parmelia caperata, P. olivacea, P. rudecta, Physcia astroidea, P. endochrysea, Ramalina calicaris.

Liverworts.—Frullania eboracensis, Radula complanata.

Mosses.—Anomodon attenuatus, A. rostratus, Dicranum flagellare, D. fulvum, D. montanum, Plagiothecium denticulatum, Platygyrium repens, Thuidium scitum, Ulota ulophylla.

11. POPULUS BALSAMIFERA.

Lichens.—Cetraria aurescens, Cladonia pyxidata, Parmelia caperata, Physcia astroidea, P. endochrysea, P. tribacia.

Liverworts.—Frullania eboracensis, Lophocolea heterophylla, Radula complanata.

Mosses.—Amblystegium serpens, Anomodon attenuatus, Brachythecium oxycladon, Campylium chrysophyllum, Fissidens adiantoides, Hypnum Haldanianum, Plagiothecium denticulatum, Platygyrium repens, Pylaisia velutina, Ulota ulophylla.

12. POPULUS TREMULOIDES.

Lichens.—Cladonia pyxidata, Graphis scripta, Parmelia caperata, P. olivacea, P. physodes, P. rudecta, Physcia astroidea, P. endochrysea.

Liverworts.—Cephalozia media, Frullania eboracensis, Lophocolea heterophylla, Lophozia ventricosa, Ptilidium pulcherrimum, Radula complanata.

Mosses.—Anomodon attenuatus, Campylium hispidulum, Brachythecium oxycladon, Campylium chrysophyllum, Dicranum flagellare, Hypnum Haldanianum, H. imponens, H. reptile, Leucodon sciuroides, Plagiothecium denticulatum, Platygyrium repens, Thuidium delicatulum

13. POPULUS GRANDIDENTATA.

Lichens.—Cladonia pyxidata, Parmelia caperata, P. olivacea, P. rudecta, Physcia endochrysea, Pyrenula nitida.

Liverworts.—Frullania eborancensis, Jamesoniella autumnalis, Lophocolea heterophylla, Ptilidium pulcherrimum, Radula complanata.

Mosses.—Brachythecium oxycladon, Dicranum flagellare, Hypnum Haldanianum, H. reptile, Plagiothecium denticulatum, Platygyrium repens, Thuidium delicatulum, Ulota ulophylla.

14. MYRICA CAROLINENSIS.

Lichens.—Buellia parasema, Cladonia pyxidata, Graphis scripta, Lecanora pallida, Parmelia olivacea, P. physodes, Pertusaria multipuncta.

Mosses.—Dicranum flagellare, Plagiothecium denticulatum, P. striatellum.

15. JUGLANS CINEREA.

Lichens.—Buellia parasema, Cladonia pyxidata, Graphis scripta, Lecanora subfusca, Lecidea vernalis, Leptogium tremelloides, Mycoblastus sanguinarius, Parmelia caperata, P. olivacea, P. perforata, P. perlata, P. physodes, P. rudecta, Peltigera canina, Physcia astroidea, P. endochrysea, P. stellaris.

Liverworts.—Cololejeunea Biddlecomiae, Frullania eboracensis, Lophocolea heterophylla, Porella platyphylloidea, Ptilidium pulcherrimum, Radula complanata.

Mosses.—Amblystegium serpens, Anomodon attenuatus, A. rostratus, Brachythecium oxycladon, Campylium chrysophyllum, Dicranum flagellare, D. fulvum, Hypnum Haldanianum, H. imponens, H. reptile, Leucodon sciuroides, Orthotrichum strangulatum, Plagiothecium denticulatum, Platygyrium repens, Pylaisia Selwynii, P. velutina, Thuidium delicatulum, Ulota ulophylla.

16. JUGLANS NIGRA.

Lichens.—Cladonia pyxidata, Graphis scripta, Parmelia caperata, P. olivacea, P. physodes, P. rudecta, Physcia endochrysea, P. stellaris.

Liverworts.—Frullania eboracensis, Ptilidium pulcherrimum, Radula complanata.

Mosses.—Brachythecium oxycladon, Dicranum flagellare, Hypnum Haldanianum, H. reptile, Platygyrium repens, Pylaisia Selwynii, Ulota ulophylla.

17. CARYA ALBA.

Lichens.—Buellia parasema, Lecanora pallida, Pertusaria multipuncta.

Mosses.—Amblystegium serpens.

18. CARYA CORDIFORMIS.

Lichens.—Buellia parasema, Cladonia pyxidata, Graphis scripta, Parmelia caperata, P. olivacea, P. rudecta, Physcia astroidea, P. endochrysea, P. stellaris.

Liverworts.—Cololejeunea Biddlecomiae, Frullania eboracensis, Lophocolea heterophylla, Porella platyphylloidea, Radula complanata.

Mosses.—Anomodon attenuatus, A. rostratus, Brachythecium oxycladon, Campylium chrysophyllum, Dicranum montanum, Fissidens adiantoides, Hypnum reptile, Plagiothecium denticulatum, Platygyrium repens, Ulota ulophylla.

19. CARYA GLABRA.

Lichens.—Buellia parasema, Cladonia pyxidata, Lecanora pallida, Lecanora subfusca, Leptogium tremelloides, Mycoblastus sanguinarius, Parmelia caperata, P. olivacea, P. physodes, P. rudecta, Peltigera canina, Physcia astroidea, P. endochrysea, Sticta pulmonaria.

Liverworts.—Cololejeunea Biddlecomiae, Frullania eboracensis, Lejeunea cavifolia, Lophocolea herteophylla, Porella platyphylloidea, Radula complanata.

Mosses.—Amblystegium serpens, Anomodon attenuatus, Brachythecium oxycladon, Campylium chrysophyllum, Dicranum flagellare, Hypnum reptile, Plagiothecium denticulatum, Platygyrium repens, Thelia asprella, Thuidium delicatulum, Ulota ulophylla.

20. CARYA OVATA.

Lichens.—Cladonia pyxidata, Graphis scripta, Parmelia caperata, P. olivacea, P. rudecta, Peltigera canina, Physicia astroidea, P. endochrysea, Pyrenula nitida, Ramalina calicaris.

Liverworts.—Frullania eboracensis, Lophocolea heterophylla, Porella platyphylloidea, Radula complanata.

Mosses.—Amblystegium serpens, Anomodon attenuatus, A. rostratus, Brachythecium oxycladon, Dicranum flagellare, Hypnum Haldanianum, Plagiothecium denticulatum, Platygyrium repens, Thuidium delicatulum.

21. OSTRYA VIRGINIANA.

Lichens.—Cladonia pyxidata, Lecanora subfusca, Parmelia caperata, P. olivacea, P. rudecta, Peltigera canina, Physcia astroidea, P. endochrysea.

Liverworts.—Cololejeunea Biddlecomiae, Frullania eboracensis, Lophocolea heterophylla, Porella platyphylloidea, Ptilidium pulcherrimum, Radula complanata.

Mosses.—Amblystegium serpens, Anomodon attenuatus, Brachythecium oxycladon, Campylium chrysophyllum, Dicranum flagellare, D. fulvum, Hypnum Haldanianum, H. imponens, H. reptile, Neckera pennata, Orthotrichum strangulatum, Plagiothecium denticulatum, Platygyrium repens, Pylaisia velutina, Thuidium delicatulum, Ulota ulophylla.

22. CARPINUS CAROLINIANA.

Lichens.—Buellia parasema, Cladonia pyxidata, Graphis scripta, Lecidea vernalis, Parmelia caperata, P. olivacea, P. physodes, P. rudecta, Physcia astroidea, P. endochrysea.

Liverworts.—Frullania eboracensis, Lophocolea heterophylla, Porella platyphylloidea, Ptilidium pulcherrimum, Radula complanata.

Mosses.—Anomodon attenuatus, A. rostratus, Brachythecium oxycladon, Campyllium chrysophyllum, Dicranum flagellare, D. fulvum, Hypnum Haldanianum H. reptile, Orthotrichum strangulatum, Plagiothecium denticulatum, Platygyrium repens, Pylaisia Selwynii, Thuidium delicatulum, Ulota ulophylla.

23. BETULA LENTA.

Lichens.—Buellia parasema, Cladonia pyxidata, Evernia prunastri, Graphis scripta, Mycoblastus sanguinarius, Parmelia caperata, P. olivacea, P. perlata, P. physodes, P. rudecta, Physcia endochrysea.

Liverworts.—Bazzania trilobata, Frullania eboracensis, Lophocolea heterophylla, Porella platyphylloidea, Ptilidium pulcherrimum, Radula complanata.

Mosses.—Ambylstegium serpens, Brachythecium oxycladon, Dicranum flagellare, D. fulvum, D. montanum, Hypnum Haldanianum, H. imponens, H. reptile, Plagiothecium denticulatum, Platygyrium repens, Ulota ulophylla.

24. BETULA LUTEA.

Lichens.—Alectoria jubata, Buellia parasema, Cetraria ciliaris, C. juniperina, Cladonia pyxidata, C. rangiferina, Evernia furfuracea, E. prunastri, Graphis scripta, Lecanora pallida, L. subfusca, Lecidea vernalis, Mycoblastus sanguinarius, Parmelia caperata, P. cetrata, P. olivacea, P. perlata, P. physodes, P. rudecta, Peltigera canina, Pertusaria multipuncta, Physcia endochrysea, Pyrenula nitida, Sticta pulmonaria, Usnea barbata.

Liverworts.—Bazzania trilobata, Cololejeunea Biddlecomiae, Frullania asagrayana, F. eboracensis, Jamesonialla autumnalis, Lophocolea heterophylla, Lophozia ventricosa,

Porella platyphylloidea, Ptilidium pulcherrimum, Radula complanata, Riccardia latifrons.

Mosses.—Amblystegium serpens, Anomodon attenuatus, Brachythecium Starkei, Brotherella recurvans, Brachythecium oxycladon, Campylium chrysophyllum, Dicranum flagellare, D. fulvum, D. fuscescens, D. longifolium, D. montanum, Drepanocladus uncinatus, Hypnum cupressiforme, H. Haldanianum, Neckera pennata, Orthotrichum strangulatum, Plagiothecium denticulatum, P. striatellum, Platygyrium repens, Thuidium delicatulum, Ulota ulophylla.

25. BETULA PAPYRIFERA.

Lichens.—Alectoria jubata, Cetraria ciliaris, Cetraria juniperina, Cladonia pyxidata, Cladonia rangiferina, Evernia furfuracea, Graphis scripta, Mycoblastus sanguinarius, Parmelia caperata, P. cetrata, P. olivacea, P. physodes, Pertusaria multipuncta, Physcia endochrysea, Usnea barbata.

Liverworts.—Frullania eboracensis, Jamesoniella autumnalis, Lepidozia reptans, Lophocolea minor, Lophozia attenuata, L. ventricosa, Ptilidium pulcherrimum.

Mosses.—Brotherella recurvans, Campylium chrysophyllum, Dicranum flagellare, D. fuscescens, D. longifolium, Hypnum cristacastrensis, H. imponens, H. pallescens, H. Schreberi, Neckera pennata, Plagiothecium denticulatum, Plagiothecium striatellum, Platygyrium repens, Pylaisia Selwynii, Ulota ulophylla.

26. BETULA POPULIFOLIA.

Lichens.—Cladonia pyxidata.

Liverworts.—Lophocolea heterophylla, Ptilidium pulcherrimum.

Mosses.—Campylium chrysophyllum, Plagiothecium denticulatum.

27. ALNUS CRISPA.

Lichens.—Cetraria ciliaris, C. juniperina, Parmelia caperata, P. cetrata, P. olivacea, P. physodes.

Liverworts.—Ptilidium pulcherrimum.

Mosses.—Dicranum longifolium.

28. ALNUS INCANA.

Lichens.—Cladonia pyxidata, Parmelia caperata, P. olivacea, P. physodes, P. rudecta, Physcia endochrysea.

Liverworts.—Jamesoniella autumnalis, Lophocolea heterophylla.

Mosses.—Campylium chrysophyllum, Dicranum flagellare, Hypnum Haldanianum, H. imponens, H. reptile, Plagiothecium denticulatum, Platygyrium repens, Ulota ulophylla.

29. FAGUS GRANDIFOLIA.

Lichens.—Buellia parasema, Cladonia pyxidata, Graphis scripta, Lecanora pallida, Mycoblastus sanguinarius, Parmelia caperata, P. olivacea, P. rudecta, Physcia endochrysea, Pyrenula nitida, Ramalina calicaris.

Liverworts.—Frullania eboracensis, Jamesoniella autumnalis, Lophocolea heterophylla, Porella platyphylloidea, Ptilidium pulcherrimum, Radula complanata.

Mosses.—Anomodon attenuatus, A. rostratus, A. Rugellii, Brachythecium Starkei, B. oxycladon, Dicranum flagellare, D. fulvum, D. fuscescens, D. longifolium, D. montanum, Hypnum Haldanianum, H. imponens, H. pallescens, H. reptile, Plagiothecium denticulatum, P. striatellum, Platygyrium repens, Thuidium delicatulum, Ulota ulophylla.

30. QUERCUS ALBA.

Lichens.—Buellia parasema, Cladonia pyxidata, Graphis scripta, Lecanora pallida, Leptogium tremelloides, Mycoblastus sanguinarius, Parmelia caperata, P. olivacea, P. rudecta, Peltigera canina, Physcia astroidea, P. endochrysea, P. stellaris, Pyrenula nitida.

Liverworts.—Cololejeunea Biddlecomiae, Frullania eboracensis, Lophocolea heterophylla, Porella platyphylloidea, Ptilidium pulcherrimum, Radula complanata.

Mosses.—Amblystegium serpens, A. varium, Anomodon attenuatus, A. rostratus, Brachythecium oxycladon, Campylium chrysophyllum, Dicranum flagellare, D. fulvum, Hypnum Haldanianum, H. imponens, H. reptile, Leucodon sciuroides, Orthotrichum strangulatum, Plagiothecium denticulatum, Platygyrium repens, Pylaisia velutina, Rhodobryum roseum, Thelia asprella, T. hirtella, Thuidium delicatulum, Ulota ulophylla.

31. QUERCUS BICOLOR.

Lichens.—Cladonia pyxidata, Parmelia caperata, P. olivacea, P. rudecta, Peltigera canina, Physcia astroidea, P. endochrysea.

Liverworts.—Lophocolea heterophylla, Frullania eboracensis, Radula complanata.

Mosses.—Anomodon attenuatus, Brachythecium oxycladon, Campylium chrysophyllum, Dicranum montanum, Hypnum Haldanianum, Plagiothecium denticulatum, Platygyrium repens, Ulota ulophylla.

32. QUERCUS BOREALIS.

Lichens.—Buellia parasema, Cladonia pyxidata, Evernia prunastri, Graphis scripta, Lecanora pallida, Parmelia caperata, P. olivacea, P. perlata, P. pertusa, P. physodes, P. rudecta, Physcia astroidea, P. endochrysea, P. tribacia.

Liverworts.—Frullania eboracensis, Jamesoniella autumnalis, Lophocolea heterophylla, Porella platyphylloidea, Ptilidium pulcherrimum, Radula complanata, Riccardia pinguis.

Mosses.—Amblystegium serpens, Anomodon attenuatus, A. rostratus, Brachythecium oxycladon, Dicranum flagellare, D. fulvum, D. montanum, Hypnum Haldanianum, H. imponens, Plagiothecium denticulatum, Plagiothecium striatellum, Platygyrium repens, Pylaisia velutina, Rhodobryum roseum, Thuidium delicatulum, Ulota ulophylla.

33. QUERCUS COCCINEA.

Lichens.—Buellia parasema, Cladonia pyxidata, Mycoblastus sanguinarius, Parmelia caperata, P. olivacea, P. physodes, P. rudecta, Physcia astroidea, P. endochrysea.

Liverworts.—Frullania eboracensis, Lophocolea heterophylla, Porella platyphylloidea, Ptilidium pulcherrimum, Radula complanata.

Mosses.—Amblystegium serpens, Brachythecium oxycladon, Dicranum flagellare, D. fulvum, Hypnum Haldanianum, Plagiothecium denticulatum, Platygyrium repens, Pylaisia Selwynii, Thuidium delicatulum, Ulota ulophylla.

34. QUERCUS MONTANA.

Lichens.—Cladonia pyxidata, Graphis scripta, Lecanora subfusca, Parmelia caperata, P. olivacea, P. physodes, P. rudecta, Physcia astroidea, P. endochrysea, Pyrenula nitida.

Liverworts.—Cololejeunea Biddlecomiae, Frullania eboracensis, Jamesoniella autumnalis, Lophocolea heterophylla, Ptilidium pulcherrimum, Radula complanata.

Mosses.—Anomodon attenuatus, A. rostratus, Brachythecium oxycladon, Dicranum flagellare, Dicranum fulvum, Hypnum Haldanianum, H. imponens, H. reptile, Plagiothecium denticulatum, Platygyrium repens, Thuidium delicatulum, Ulota ulophylla.

35. QUERCUS STELLATA.

Lichens.—Cladonia pyxidata, Parmelia caperata, P. olivacea.

Liverworts.—Frullania eboracensis.

Mosses.—Anomodon rostratus, Dicranum flagellare, Plagiothecium denticulatum, Thelia hirtella.

36. QUERCUS VELUTINA.

Lichens.—Cladonia pyxidata, Lecanora pallida, Parmelia caperata, P. olivacea, P. physodes, P. rudecta, Physcia astroidea, P. endochrysea.

Liverworts.—Frullania eboracensis, Lophocolea heterophylla, Porella platyphylloidea, Radula complanata.

Mosses.—Anomodon attenuatus, Brachythecium oxycladon, Dicranum flagellare, Plagiothecium denticulatum, Platygyrium repens, Thelia hirtella, Ulota ulophylla.

37. ULMUS AMERICANA.

Lichens.—Cetraria aurescens, Cladonia pyxidata, Graphis scripta, Lecanora subfusca, Lecidea vernalis, Leptogium tremelloides, Mycoblastus sanguinarius, Parmelia caperata, P. olivacea, P. perlata, P. physodes, P. rudecta, Peltigera canina, Physcia astroidea, P. endochrysea, P. stellaris, Pyrenula nitida, Ramalina calicaris, R. pollinaris, Sticta pulmonaria.

Liverworts.—Cololejeunea Biddlecomiae, Frullania eboracensis, Lophocolea heterophylla, Porella platyphylla, P. platyphylloidea, Plagiochila asplenioides, Porella platyphylloidea, Ptilidium pulcherrimum, Radula complanata, Trichocolea tomentella.

Mosses.—Amblystegium serpens, Anomodon attenuatus, A. Rugellii, Brachythecium oxycladon, Campylium chrysophyllum, Dicranum flagellare, D. montanum, Fissidens adiantoides, Dicranum fulvum, Hypnum Haldanianum, H. imponens, H. reptile, Leucodon sciuroides, Neckera pennata, Orthotrichum strangulatum, Plagiothecium denticulatum, Platygyrium repens, Pylaisia Selwynii, P. velutina, Rhodobryum roseum, Thelia asprella, Thuidium delicatulum, Ulota ulophylla.

38. ULMUS FULVA.

Lichens.—Cetraria aurescens, Cladonia pyxidata, Physcia endochrysea.

Liverworts.—Frullania eboracensis, Porella platyphylloidea, Radula complanata.

Mosses.—Amblystegium serpens, Anomodon attenuatus, Brachythecium oxycladon, Campylium chrysophyllum, Plagiothecium denticulatum, Platygyrium repens, Thuidium delicatulum.

39. MAGNOLIA ACUMINATA.

Lichens.—Cladonia pyxidata, Parmelia caperata, P. olivacea, P. physodes, P. rudecta, Physcia astroidea, P. endochrysea.

Liverworts.—Frullania eboracensis, Jamesoniella autumnalis, Ptilidium pulcherrimum, Radula complanata.

Mosses.—Amblystegium serpens, Dicranum flagellare, Hypnum imponens, H. reptile, Orthotrichum strangulatum, Plagiothecium denticulatum, Platygyrium repens, Ulota ulophylla.

40. LIRIODENDRON TULIPIFERA.

Lichens.—Cladonia pyxidata, Evernia prunastri, Graphis scripta, Mycoblastus sanguinarius, Parmelia caperata, P. olivacea, P. physodes, P. rudecta, Peltigera canina, Physcia astroidea, P. endochrysea, Ramalina calicaris, Usnea barbata.

Liverworts.—Frullania eboracensis, Lophocolea heterophylla, Porella platyphylloidea, Ptiilidium pulcherrimum, Radula complanata.

Mosses.—Amblystegium serpens, Anomodon attenuatus, A. rostratus, Brachythecium oxycladon, Campylium chrysophyllum, Dicranum flagellare, D. fulvum, D. montanum, Hypnum Haldanianum, H. imponens. Plagiothecium denticulatum, Platygyrium repens, Ulota ulophylla.

41. SASSAFRAS OFFICINALE.

Lichens.—Cladonia pyxidata.

Liverworts.—Lophocolea heterophylla.

Mosses.—Dicranum flagellare, Hypnum imponens, Plagiothecium denitculatum, P. striatellum, Platygyrium repens.

42. PLATANUS OCCIDENTALIS.

Lichens.—Cladonia pyxidata, Parmelia caperata, Physcia endochrysea, Pyrenula nitida.

Liverworts.—Cololejeunea Biddlecomiae, Frullania eboracensis, Lophocolea heterophylla, Radula complanata.

Mosses.—Amblystegium serpens, Anomodon attenuatus, Anomodon rostratus, Brachythecium oxycladon, Campylium chrysophyllum, Hypnum Haldanianum, H. imponens, H. reptile, Plagiothecium denticulatum, Platygyrium repens, Pylaisia Selwynii, Thuidium delicatulum, Ulota ulophylla.

43. AMELANCHIER CANADENSIS.

Lichens.—Buellia parasema, Cladonia pyxidata, Evernia prunastri, Graphis scripta, Parmelia caperata, P. olivacea, P. physodes, P. rudecta.

Liverworts.—Cololejeunea Biddlecomiae, Frullania eboracensis, Jamesoniella autumnalis, Lophocolea heterophylla, Ptilidium pulcherrimum, Radula complanata.

Mosses.—Brachythecium oxycladon, Campylium chrysophyllum, Dicranum flagellare, Hypnum Haldanianum, H. imponens, H. reptile, Plagiothecium denticulatum, Platygyrium repens, Thuidium delicatulum.

44. AMELANCHIER OBLONGIFOLIA.

Lichens.—Buellia parasema, Cladonia pyxidata, Lecanora pallida, Parmelia rudecta.

Liverworts.—Jamesoniella autumnalis.

Mosses.—Dicranum flagellare, Plagiothecium denticulatum, P. striatellum, Thelia hirtella.

45. MALUS PUMILA.

Lichens.—Buellia parasema, Cladonia pyxidata, Parmelia caperata, P. olivacea, P. physodes, P. rudecta, Physcia astroidea, P. endochrysea, P. stellaris.

Liverworts.—Frullania eboracensis, Lophocolea heterophylla, Porella platyphylloidea, Radula complanata.

Mosses.—Amblystegium serpens, Anomodon Rugellii, A. rostratus, Brachythecium oxycladon, Campylium chrysophyllum, Hypnum Haldanianum, Orthotrichum strangulatum, Plagiothecium denticulatum, Platygyrium repens, Pylaisia Selwynii, P. velutina, Thudium delicatulum, Ulota ulophylla.

46. PRUNUS SEROTINA.

Lichens.—Cladonia pyxidata, Evernia prunastri, Graphis scripta, Lecanora pallida, L. subfusca, Lecidea vernalis, Parmelia caperata, P. olivacea, P. physodes P. rudecta, Physcia astroidea, P. endochrysea.

Liverworts.—Frullania eboracensis, Jamesoniella autumnalis, Lophocolea heteropylla, Riccardia latifrons, Ptilidium pulcherrimum.

Mosses.—Amblystegium serpens, Brotherella recurvans, Brachythecium oxycladon, Campylium chrysophyllum, Dicranum flagellare, D. fulvum, D. longifolium, Hypnum imponens, H. reptile, Plagiothecium denticulatum, P. striatellum, Platygyrium repens, Thudium delicatulum, Ulota ulophylla.

47. PRUNUS VIRGINIANA.

Lichens.—Cladonia pyxidata, Parmelia olivacea, P. rudecta.

Liverworts.—Lophocolea heterophylla, Ptilidium pulcherrimum.

Mosses.—Dicranum flagellare, Hypnum imponens, H. pallescens, Plagiothecium denticulatum, Platygyrium repens, Ulota ulophylla.

48. PYRUS COMMUNIS.

Lichens.—Cladonia pyxidata, Parmelia rudecta.

Liverworts.—Lophocolea heterophylla, Ptilidium pulcherrimum.

Mosses.—Brachythecium oxycladon, Dicranum flagellare, Plagiothecium denticulatum, Platygyrium repens.

49. SORBUS AMERICANA.

Lichens.—Alectoria jubata, Buellia parasema, Cetraria ciliaris, Cladonia pyxidata, Evernia furfuracea, E. prunastri, Graphis scripta, Lecanora pallida, Mycoblastus sanguinarius, Parmelia caperata, P. cetrata, P. olivacea, P. perlata, P. physodes, Ramalina pollinaria, Usnea barbata.

Liverworts.—Frullania Asagrayana, Frullania eboracensis, Jamesoniella autumnalis, Lophocolea heterophylla, Ptilidium pulcherrimum.

Mosses.—Brachythecium Starkei, Dicranum flagellare, D. fuscescens, D. longifolium, Hypnum imponens, H. pallescens, H. reptile, Plagiothecium denticulatum, P. striatellum, Platygyrium repens, Thudium delicatulum, Ulota ulophylla.

50. ROBINIA PSEUDO-ACACIA.
Lichens.—Cladonia pyxidata, Parmelia caperata, Physcia astroidea, P. endochrysea.
Liverworts.—Frullania eboracensis.
Mosses.—Anomodon attenuatus, Platygyrium repens, Ulota ulophylla.

51. RHUS VERNIX.
Lichens.—Parmelia caperata, P. olivacea, P. physodes, P. rudecta.
Liverworts.—Lophocolea heterophylla, Ptilidium pulcherrimum.
Mosses.—Plagiothecium denticulatum, Thuidium delicatulum, Ulota ulophylla.

52. ACER PENNSYLVANICUM.
Lichens.—Cladonia pyxidata, Parmelia caperata, P. olivacea, P. physodes, Peltigera canina, Physcia endochrysea.
Liverworts.—Frullania Asagrayana, Frullania eboracensis, Ptilidium pulcherrimum.
Mosses.—Brotherella recurvans, Dicranum flagellare, Depranocladus uncinatus, Hypnum pallescens, H. reptile, Plagiothecium denticulatum, P. striatellum, Platygyrium repens, Thuidium delicatulum, Ulota Ludwigii, U. ulophylla.

53. ACER RUBRUM.
Lichens.—Buellia parasema, Cladonia pyxidata, Evernia prunastri, Graphis scripta, Lecanora pallida, L. subfusca, Lecidea vernalis, Leptogium tremelloides, Parmelia caperata, P. olivacea, P. perlata, P. pertusa, P. physodes, P. rudecta, Peltigera canina, Pertusaria multipuncta, Physcia astroidea, P. endochrysea, Sticta pulmonaria, Usnea barbata.
Liverworts.—Bazzania trilobata, Cephalozia media, Chiloscyphus polyanthus, Frullania Asagrayana, F. eborancensis, Jamesoniella autumnalis, Lophocolea heterophylla, L. minor, Porella pinnata, P. platyphylla, Ptilidium pulcherrimum, Radula complanata.
Mosses.—Amblystegium serpens, Anomodon attenuatus, A. rostratus, Brachythecium oxycladon, Campylium chrysophyllum, Dicranum flagellare, D. fulvum, D. montanum, Drepanocladus uncinatus, Hypnum Haldanianum, H. imponens, H. pallescens, H. reptile, Leptodictyum riparium, Plagiothecium denticulatum, P. striatellum, Platygyrium repens, Pylaisia Selwynii, Thelia hirtella, Thuidium delicatulum, Ulota ulophylla.

54. ACER SACCHARUM.
Lichens.—Anaptychia aquila var. detonsa, Arthothelium spectabile, Buellia parasema, Cetraria juniperina, Cladonia pyxidata, Graphis scripta, Lecanora subfusca, Lecidea vernalis, Leptogium tremelloides, Mycoblastus sanguinarius, Parmelia caperata, P. olivacea, P. perforata, P. physodes, P. rudecta, Peltigera canina, Physcia astroidea, P. endochrysea, P stellaris, Pyrenula nitida, Ramalina calicaris, Sticta pulmonaria.
Liverworts.—Cololejeunea Biddlecomiae, Frullania eboracensis, Lophocolea heterophylla, Porella platyphylloidea, Ptilidium pulcherrimum, Radula complanata, Riccardia latifrons.
Mosses.—Anomodon attenuatus, A. Rugelii, Brachythecium Starkei, Anomodon rostratus, Brachythecium oxycladon, Campylium chrysophyllum, Dicranum flagellare, Dicranum fulvum, D. fuscescens, Hypnum Haldanianum, H. imponens, H. pallescens, H. reptile, Neckera pennata, Plagiothecium denticulatum, P. striatellum, Platygyrium repens, Pterigynandrum filiforme, Pylaisia Selwynii, Thuidium scitum, Ulota ulophylla.

55. TILIA AMERICANA.
Lichens.—Buellia parasema, Cladonia pyxidata, Graphis scripta, Lecanora subfusca, Lecidea vernalis, Leptogium tremelloides, Mycoblastus sanguinarius, Parmelia caperata, P. olivacea, P. perlata, P. physodes, P. rudecta, Peltigera canina, Physcia astroidea, P. endochrysea, Pyrenula nitida, Ramalina calicaris.
Liverworts.—Cololejeunea Biddlecomiae, Frullania eboracensis, Lophocolea heterophylla, Porella platyphylloidea, Ptilidium pulcherrimum, Radula complanata.
Mosses.—Amblystegium serpens, Anomodon attenuatus, A. rostratus, Brotherella recurvans, Brachythecium oxycladon, Campylium chrysophyllum, Dicranum flagellare. D. fulvum, D. montanum, Hypnum Haldanianum, H. imponens, H. reptile, Leucodon

sciuroides, Orthotrichum strangulatum, Plagiothecium denticulatum, Platygyrium repens, Pylaisia velutina, Thuidium delicatulum, Ulota ulophylla.

56. NYSSA SYLVATICA.

Lichens.—Lecanora pallida, Parmelia caperata, P. olivacea, P. rudecta, Physcia astroidea, Sticta pulmonaria.

Liverworts.—Frullania eboracensis, Lophocolea heterophylla.

Mosses.—Anomodon attenuatus, Brachythecium oxycladon, Dicranum flagellare, Plagiothecium denticulatum, P. striatellum, Platygyrium repens, Thelia hirtella.

57. CORNUS FLORIDA.

Lichens.—Cladonia pyxidata, Physcia endochrysea.

Liverworts.—Frullania eboracensis, Porella platyphylloidea, Radula complanata.

Mosses.—Anomodon attenuatus, A. rostratus, Campylium chrysophyllum, Hypnum Haldanianum, H. reptile, Plagiothecium denticulatum, Platygyrium repens, Pylaisia velutina.

58. RHODODENDRON MAXIMUM.

Lichens.—Cladonia pyxidata, Physcia endochrysea.

Liverworts.—Ptilidium pulcherrimum.

Mosses.—Dicranum flagellare, D. fulvum, Hypnum imponens, Platygyrium repens.

59. KALMIA LATIFOLIA.

Lichens.—Cladonia pyxidata, Evernia prunastri, Lecanora pallida, Parmelia caperata, P. pertusa, P. physodes.

Liverworts.—Bazzania trilobata, Jamesoniella autumnalis, Lophocolea heterophylla, Ptilidium pulcherrimum.

Mosses.—Dicranum flagellare, D. fulvum, Hypnum imponens, Plagiothecium denticulatum, Platygyrium repens, Thuidium delicatulum.

60. FRAXINUS AMERICANA.

Lichens.—Cladonia pyxidata, Graphis scripta, Lecanora subfusca, Lecidea vernalis, Leptogium tremelloides, Mycoblastus sanguinarius, Parmelia caperata, P. olivacea, P. physodes, P. rudecta, Peltigera canina, Physcia astroidea, P. endochrysea, P. stellaris, Pyrenula nitida, Ramalina calicaris.

Liverworts.—Cephalozia media, Cololejeunea Biddlecomiae, Frullania eboracensis, Lophocolea heterophylla, Porella platyphylloidea, Ptilidium pulcherrimum, Radula complanata.

Mosses.—Amblystegium serpens, Anomodon attenuatus, A. rostratus, A. Rugelii, Brachythecium oxycladon, Brotherella recurvans, Campylium chrysophyllum, Dicranum flagellare, D. fulvum, D. longifolium, Fissidens adiantoides, Hypnum Haldanianum, H. imponens, H. reptile, Neckera pennata, Orthotrichum strangulatum, Plagiothecium denticulatum, Platygyrium repens, Pylaisia Selwynii, P. velutina, Rhodobryum roseum, Thuidium delicatulum, Ulota ulophylla.

61. FRAXINUS NIGRA.

Lichens.—Cladonia pyxidata, Graphis scripta, Parmelia caperata, P. olivacea, P. physodes, P. rudecta, Peltigera canina, Physcia astroidea, P. endochrysea, P. stellaris, Leptogium tremelloides.

Liverworts.—Frullania eboracensis, Lophocolea heterophylla, Porella platyphylloidea, Ptilidium pulcherrimum, Radula complanata.

Mosses.—Amblystegium serpens, Anomodon attenuatus, A. rostratus, Brachythecium oxycladon, Climacium americanum, Campylium chrysophyllum, Dicranum flagellare, Hypnum Haldanianum, H. imponens, H. reptile, Leucodon sciuroides, Plagiothecium denticulatum, Platygyrium repens, Pylaisia Selwynii, P. velutina, Rhodobryum roseum, Thuidium delicatulum, Ulota ulophylla.

TABLE 2.—The number of species of epiphytes on each host and the percentage of stations at which epiphytes were collected from each.

	Species	Lichens	Liverworts	Mosses	Total	Percentage of stations where host was collected from
1	Pinus resinosa	1	0	4	5	20
2	Pinus rigida	10	0	2	12	32
3	Pinus strobus	11	4	8	23	76
4	Picea mariana	11	0	0	11	4
5	Picea rubra	13	7	10	30	20
6	Abies balsamea	17	7	11	35	20
7	Larix laricina	14	3	6	23	20
8	Tsuga canadensis	9	6	13	28	64
9	Thuja occidentalis	10	15	19	44	20
10	Juniperus virginiana	8	2	9	19	28
11	Populus balsamifera	6	3	10	19	24
12	Populus tremuloides	8	12	12	32	68
13	Populus grandidentata	6	5	8	19	60
14	Myrica carolinensis	7	0	3	10	16
15	Juglans cinerea	17	6	18	41	68
16	Juglans nigra	8	3	7	18	20
17	Carya alba	3	0	1	4	4
18	Carya cordiformis	9	5	10	24	40
19	Carya glabra	14	6	11	31	36
20	Carya ovata	10	4	9	23	44
21	Ostrya virginiana	8	6	17	31	72
22	Carpinus caroliniana	10	5	14	29	72
23	Betula lenta	11	6	11	28	56
24	Betula lutea	25	11	25	61	88
25	Betula papyrifera	15	7	15	37	32
26	Betula populifolia	1	2	2	5	8
27	Alnus crispa	6	1	1	8	12
28	Alnus incana	6	2	8	16	20
29	Fagus grandifolia	11	6	19	36	88
30	Quercus alba	14	6	21	41	68
31	Quercus bicolor	7	3	8	18	12

(TABLE 2.—(*Continued*)

	Species	Lichens	Liverworts	Mosses	Total	Percentage of stations where host was collected from
32	Quercus borealis	14	7	17	38	68
33	Quercus coccinea	9	6	11	26	28
34	Quercus montana	10	6	12	28	32
35	Quercus stellata	3	1	4	8	4
36	Quercus velutina	8	4	7	19	32
37	Ulmus americana	20	10	23	53	68
38	Ulmus fulva	3	3	7	13	20
39	Magnolia acuminata	7	4	8	19	36
40	Liriodendron tulipifera	13	5	13	31	36
41	Sassafras officinale	1	1	5	7	24
42	Platanus occidentalis	4	4	13	21	32
43	Amelanchier canadensis	8	6	9	23	52
44	Amelanchier oblongifolia	4	1	4	9	4
45	Malus pumila	9	4	13	26	36
46	Prunus serotina	12	5	14	31	88
47	Prunus virginiana	3	2	6	11	40
48	Pyrus communis	2	2	4	8	4
49	Sorbus americana	16	6	12	34	32
50	Robinia-Pseudo-acacia	4	1	13	18	8
51	Rhus vernix	4	2	3	9	20
52	Acer pennsylvanicum	6	3	11	20	28
53	Acer rubrum	20	12	21	53	80
54	Acer saccharum	22	7	21	51	80
55	Tilia americana	17	6	19	42	68
56	Nyssa sylvatica	6	2	7	15	8
57	Cornus florida	2	3	8	13	40
58	Rododendron maximum	2	1	4	7	4
59	Kalmia latifolia	6	4	6	16	20
60	Fraxinus americana	16	7	23	46	84
61	Fraxinus nigra	11	5	18	34	48
62	Fraxinus pennsylvanica	8	4	10	22	12
63	Cephalanthus occidentalis	7	1	5	13	24

62. FRAXINUS PENNSYLVANICA.

Lichens.—Cladonia pyxidata, Graphis, scripta, Parmelia caperata, P. olivacea, P. physodes, P. rudecta, Physcia astroidea, P. endochrysea.

Liverworts.—Bazzania trilobata, Frullania eboracensis, Lophocolea heterophylla, Radula complanata.

Mosses.—Amblystegium varium, Anomodon attenuatus, Brachythecium oxycladon, Campylium chrysophyllum, Dicranum flagellare, Hypnum imponens, Leptodictyum riparium, Plagiothecium denticulatum, Platygyrium repens, Ulota ulophlyla.

63. CEPHALANTHUS OCCIDENTALIS.

Lichens.—Cladonia pyxidata, Parmelia caperata, P. olivacea, P. physodes, P. rudecta, Physcia astroidea, P. endochrysea.

Liverworts.—Frullania eboracensis.

Mosses.—Climacium Kindbergii, Leptodictyum riparium, Plagiothecium denticulatum, P. striatellum, Thelia hirtella.

Discussion and Summary

The 25 stations at which studies of epiphytes were made mostly fall into four natural groups such as gorges, swamps, hilltops, mountains and two miscellaneous ones. The general features of each group of stations are described (a) and the dominant epiphytes are listed (b). The number of lichens, liverworts, mosses and total species of epiphytes observed at each station are recorded (c).

GORGES—Stations 1-7

(a) Most of the gorges have steep sides in places consisting of nearly vertical cliffs, are from 100 to 200 feet deep and run in a general east-west direction. They present a cool, moist habitat when compared with the surrounding region. Trees of considerable size and age especially on the south side provide a moist, shaded environment in which liverworts and mosses thrive. Lichens occur mostly in open places, on isolated trees or on those near the rims of the gorges.

(b) DOMINANT SPECIES IN GORGES

Lichens.—Parmelia caperata, Parmelia olivacea, Parmelia physodes, Parmelia rudecta, Physcia astroidea, Physcia endochrysea.

Liverworts.—Frullania eboracensis, Lophocolea heterophylla, Porella platyphylloidea, Ptilidium pulcherrimum, Radula complanata.

Mosses.—Amblystegium serpens, Anomodon attenuatus, Anomodon rostratus, Brachythecium oxycladon, Dicranum flagellare, Hypnum Haldanianum, Hypnum imponens, Plagiothecium denticulatum, Platygyrium repens, Ulota ulophylla.

(c) 1. SIX MILE: lichens 11, liverworts 8, mosses 14, total 33. 2. FALL CREEK: lichens 15, liverworts 6, mosses 17, total 38. 3. BUTTERMILK: lichens 11, liverworts 6, mosses 19, total 36. 4. COY GLEN: lichens 22, liverworts 9, mosses 19, total 50. 5. ENFIELD: lichens 20, liverworts 7, mosses 17, total 44. 6. BIG GULLY: lichens 14, liverworts 5, mosses 17, total 36. 7. CAYUTA LAKE OUTLET: lichens 20, liverworts 11, mosses 18, total 49.

SWAMPS—Stations 8-13

(a) Three of the swamps, Michigan Hollow, Headwaters and McLean Bogs, represent filled in depressions among morainic deposits on the divide between the St. Lawrence and the Susquehanna drainage systems. They contain both acid sphagnum areas and marly portions, thus affording a variety of host

species in the soft, wet depressions as well as on the surrounding hard ground. The scattered trees in the open bogs support lichens in abundance while mosses and liverworts are common on trees of more densely forested areas. Bergen Swamp and Junius are primarily open marl bogs on the Ontario plain. They are surrounded by acid woodland areas. Jamesville bog borders a small lake in a plunge pool in the Onondaga limestone region. Both the Bergen and the Jamesville stations have dense arborvitae, *Thuja occidentalis,* stands.

(b) DOMINANT SPECIES IN SWAMPS.

Lichens.—Cetraria ciliaris (on conifers), Evernia prunastri, Parmelia caperata, Parmelia olivacea, Parmelia physodes, Parmelia rudecta, Physcia endochrysea.

Liverworts.—Frullania eboracensis, Lophocolea heterophylla, Porella platyphylloidea, Ptilidium pulcherrimum. Radula complanata.

Mosses.—Amblystegium serpens, Anomodon attenuatus, Brachythecium oxycladon, Dicranum flagellare, Hypnum Haldanianum, Hypnum imponens, Plagiothecium denticulatum, Platygyrium repens, Ulota ulophylla.

(c) 8. MICHIGAN HOLLOW: lichens 19, liverworts 11, mosses 23, total 53. 9. HEADWATERS: lichens 20, liverworts 7, mosses 18, total 45. 10. McLEAN BOGS: lichens 19, liverworts 7, mosses 22, total 48. 11. JUNIUS: lichens 11, liverworts 4, mosses 13, total 28. 12. BERGEN: lichens 17, liverworts 13, mosses 20, total 50. 13. JAMESVILLE: lichens 12, liverworts 8, mosses 20, total 40.

HILLS—Stations 14-17

(a) Three of the hills represent isolated remnants along the north edge of the Allegheny Plateau. The areas worked over represent the upper 200 to 400 feet of the hilltops, which varied between 1300 and 2000 feet elevation above sea-level. Both open, windswept areas with scattered trees and forested regions in somewhat protected parts are included. The soil near the tops of the hills is mostly acid and, except for South Hill, well drained. Rock City, Olean, at an elevation of about 2300 feet consists of outcroppings of Pennsylvania conglomerate broken into large blocks. The soil is very acid, well drained and supports only a limited number of tree species growing among and around the blocks of stone. A similar outcropping or "Rock City" at Salamanca, New York, was also examined but no additional or different epiphytes were found there. Most of the lichens and a few mosses are found on the individual trees in the open; the liverworts and most of the mosses occur in more protected places.

(b) DOMINANT SPECIES ON HILLS.

Lichens.—Parmelia caperata, Parmelia olivacea, Parmelia rudecta, Physcia endochrysea.

Liverworts.—Frullania eboracensis, Lophocolea heterophylla, Ptilidium pulcherrimum.

Mosses.—Dicranum flagellare, Hypnum imponens, Plagiothecium denticulatum, Platygyrium repens.

(c) 14. SOUTH HILL: lichens 8, liverworts 5, mosses 14, total 27. 15. CONNECTICUT HILL: lichens 7, liverworts 6, mosses 12, total 25. 16. SLATERVILLE: lichens 9, liverworts 8, mosses 13, total 30. 17. ROCK CITY: lichens 12, liverworts 6, mosses 12, total 30.

MOUNTAINS—Stations 18-23

(a) These include the upper slopes (4000-5300 feet elevation) of three of the higher peaks in the central Adirondacks. Dense stands of forests, mostly conifers, a few hardwoods and stunted trees in open places near the summits characterize these areas. The lower slopes especially are provided with much moisture. Low temperature, excessive winds and a short growing season are characteristic on the peaks. Indian Pass (2300-2800 feet elevation) is a narrow pass between steep, rocky slopes. The bottom of the pass is filled with enormous rocks among which ice may be found throughout the summer. The atmosphere is humid and cold. The host species are few but conditions for epiphytes are very favorable.

In the Catskill station, beginning at Stony Clove and extending to the summit of Hunter Mountain 2000-4000 feet in elevation, the hosts are limited in number, a few hardwoods on the lower slopes but dense balsam and spruce forest on the summit.

The Shawangunk mountain station at Sam's Point is a dry, exposed, rocky area the summit of which has an open growth of low pitch pine, *Pinus rigida,* and scattered hardwoods, mostly oaks. In protected places hardwoods are more common. A paucity of epiphytes is observed in the area.

On the upper slopes of the mountains the most prominent lichens observed occur chiefly on the crown, especially of coniferous species. Some of the mosses and *Ptilidium pulcherrimum* are conspicuous in extending higher on the trunks of trees than they do at lowland stations.

(b) DOMINANT SPECIES ON MOUNTAINS.

Lichens.—Alectoria jubata, Cetraria ciliaris, Cetraria juniperina, Evernia furfuracea, Evernia prunastri, Parmelia caperata, Parmelia cetrata, Parmelia olivacea, Parmelia physodes, Usnea barbata.

Liverworts.—Jamesoniella autumnalis, Ptilidium pulcherrimum.

Mosses.—Brachythecium Starkei (Adirondacks only), Brotherella recurvans, Dicranum fuscescens, Dicranum longifolium, Hypnum pallescens (Adirondacks only), Hypnum reptile, Hypnum Schreberi, Neckera pennata, Plagiothecium striatellum (Adirondacks only).

c) 18. SHAWANGUNK MTS.: lichens 9, liverworts 8, mosses 11, total 28. 19. CATSKILL MTS.: lichens 21, liverworts 11, mosses 20, total 52. 20. INDIAN PASS: lichens 22, liverworts 10, mosses 20, total 52. 21. MT. MACINTYRE: lichens 18, liverworts 8, mosses 16, total 42. 22. MT. COLDEN: lichens 13, liverworts 3, mosses 13, total 29. 23. MT. MARCY: lichens 18, liverworts 10, mosses 17, total 45.

CHAUTAUQUA LAKE—Station 24

(a) This represents the westernmost station of the study. The shores of the lake, elevation 1307 feet above sea-level, contain a variety of hosts chiefly in wet, swampy areas. The host trunks and bases afford a habitat for some of the common mosses and a few liverworts; the lichens occur on more isolated and exposed host species.

(b) DOMINANT SPECIES OF THE CHAUTAUQUA AREA.

Lichens.—Parmelia olivacea, Parmelia rudecta, Physcia astroidea, Physcia endochrysea.

Liverworts.—Fruliania eboracensis, Lophocolea heterophylla, Ptilidium pulcherrimum, Radula complanata.

Mosses.—Anomodon attenuatus, Brachythecium oxycladon, Dicranum flagellare, Hypnum imponens, Plagiothecium denticulatum, Platygyrium repens.

(c) CHAUTAUQUA LAKE: lichens 11, liverworts 5, mosses 15, total 31.

MONTAUK POINT, LONG ISLAND—Station 25

(a) The area consists of low sandy hills with a few boggy depressions. Located near sea-level and near the salt water shore the region is exposed to winds and salt spray. The number of host trees is limited and except in protected copses they are much stunted and the bark is relatively smooth even in species which in other areas may have rather rough bark. Lichens, especially crustose types, are very common although represented by a few species only. Liverworts and mosses are very rare except in low protected places.

(b) DOMINANT SPECIES ON MONTAUK POINT, L. I.

Lichens.—Buellia parasema, Lecanora pallida, Parmelia caperata, Parmelia olivacea, Parmelia physodes, Parmelia rudecta.

Liverworts.—None.

Mosses.—Climacium Kindbergii (found only here), Dicranum flagellare, Plagiothecium denticulatum, Thelia hirtella.

(c) MONTAUK POINT, L. I.: lichens 16, liverworts 3, mosses 9, total 28.

The stations at which the greatest numbers of epiphytes were found are: Michigan Hollow, 53 species; Hunter Mountain, Catskills, 52; Indian Pass, Adirondacks, 52; Bergen Swamp, 50; Coy Glen, 50; Cayuta Lake Outlet, 49; McLean Bogs, 48. In general these stations were also the places where the greatest number of species of lichens, liverworts and mosses were found. They are widely separated, present an apparent diversity of habitats and each exhibits some variations within itself. They all provide environments in which the evaporational tension is low.

Those stations in which the fewest species of epiphytes were found, Connecticut Hill, 25 species, South Hill, 27 and Sam's Point, Shawangunk mountains, 28, represent the most exposed areas in which evaporational tension would be expected to be very high.

The data reveal that the dominant species of epiphytes of swamps and gorges are quite similar. Foliose lichens dominate in both types of stations. *Cetraria ciliaris* and *Evernia prunastri* were found only on conifers in swamps and not at all in gorges. The liverworts and mosses for both types of stations were much the same, though *Anomodon rostratus* was dominant in gorges and not in swamps. Stations on hills showed fewer lichens, liverworts and mosses while at Chautauqua Lake the dominant species of all three groups were the same as those of hills, swamps and gorges. Dominant lichens in the mountains were most numerous and most varied; here there were fewer dom-

inant liverworts, and the mosses, though in general belonging to the same genera as the dominant species of the above-mentioned stations, were different species. Two crustose lichen forms were dominant on Montauk Point along with the common foliose types, but there were no dominant liverworts. Two mosses not found elsewhere, *Climacium Kindbergii* and *Thelia hirtella*, were dominant along with some more generally distributed.

These data indicate the rather wide distribution of some species of epiphytes, also the restricted distribution of others. The former represent the more tolerant species which find adequate environments in many places, the latter apparently find favorable situations in only limited areas.

Certainly all of these dominant species can be called true epiphytes, since observations indicate that they occur more than occasionally or accidentally on host species. To attempt to classify them as obligate or facultative epiphytes would necessitate further study though observations indicate that many of them are facultative since they have been noted on substrata other than living trees and shrubs. Intensive study of these other substrata would provide the data for determining the obligate or facultative nature of the epiphytic species found in the present study.

The distribution data by stations and hosts show the irregular nature of the distribution of epiphytes. Thirty-one of the epiphytic lichens were observed at only one to 15 of the 25 stations. Also 31 of the lichens were found on 1/3 or fewer of the host species.

Twenty of the epiphytic liverworts were observed at from 1-15 of the stations and on 1/3 or fewer of the hosts. Of the mosses, 32 species were observed at 15 or fewer stations and on 1/3 or fewer of the hosts. These data indicate that there are few epiphytes in New York with a wide distribution and few occurring on many of the possible host plants. In other words, no large number of lichens, liverworts or mosses occurs epiphytically at the majority of the stations or on the majority of the hosts. On the other hand, 6 lichens, 5 liverworts and 9 mosses appear to be quite widely distributed throughout New York state on a variety of trees. One alga, *Protococcus viridis*, is widely distributed and occurs on many hosts. *Cladonia pyxidata*, the most widely distributed epiphytic lichen, occurred as generally, if not more so, on other substrata at the several stations as it did on trees. *Thuidium delicatulum*, a common moss on moist soil and decaying wood, although widespread on the lower parts of many hosts, seldom occurred in great abundance as an epiphyte.

The most common eiphytes observed on 63 hosts at 25 selected stations in New York:

1. LICHENS.
   Parmelia physodes at 23 stations on 39 hosts.
   Parmelia rudecta at 20 stations on 44 hosts.
   Parmelia olivacea at 24 stations on 47 hosts.
   Parmelia caperata at 25 stations on 52 hosts.
   Physcia endochrysea at 24 stations on 41 hosts.
   Cladonia pyxidata at 25 stations on 59 hosts.
2. ALGAE.
   Protococcus viridis at 23 stations on 61 hosts.

3. LIVERWORTS.
   Frullania eboracensis at 24 stations on 43 hosts.
   Lophocolea heterophylla at 23 stations on 44 hosts.
   Porella platyphylloidea at 20 stations on 25 hosts.
   Ptilidium pulcherrimum at 22 stations on 39 hosts.
   Radula complanata at 19 stations on 37 hosts.

4. MOSSES.
   Plagiothecium denticulatum found at 25 stations on 55 hosts.
   Hypnum reptile found at 23 stations on 33 hosts.
   Platygyrium repens found at 22 stations on 52 hosts.
   Ulota ulophylla found at 22 stations on 35 hosts.
   Hypnum imponens found at 22 stations on 32 hosts.
   Dicranum flagellare found at 21 stations on 49 hosts.
   Brachythecium oxycladon found at 20 stations on 38 hosts.
   Thuidium delicatulum found at 19 stations on 29 hosts.
   Anomodon attenuatus found at 19 stations on 33 hosts.

The host species on which more than 40 species of epiphytes were found are the following:

Betula lutea	61 epiphytes	Thuja occidentalis	44 epiphytes
Ulmus americana	53 epiphytes	Tilia americana	42 epiphytes
Acer rubrum	53 epiphytes	Juglans cinerea	41 epiphytes
Acer saccharum	50 epiphytes	Quercus alba	41 epiphytes
Fraxinus americana	46 epiphytes		

The host species on which fewer than 10 species of epiphytes were found are the following:

Carya alba	4 epiphytes	Pyrus communis	8 epiphytes
Betula populifolia	5 epiphytes	Quercus stellata	8 epiphytes
Pinus resinosa	5 epiphytes	Alnus crispa	8 epiphytes
Sassafras officinale	7 epiphytes	Amelanchier oblongifolia	9 epiphytes
Rhododendron maximum	7 epiphytes	Rhus vernix	9 epiphytes

There appears to be a correlation between the host species on which the greatest number of epiphytes were found and the number of stations at which individuals were examined. Of the nine host species on which more than 40 species of epiphytes were found, all except *Thuja occidentalis* were collected from at 68% or more of the stations. (See Table 2, page 485). *Thuja occidentalis* was collected from at only 20% of the stations.

Host species having fewer than ten species of epiphytes were all collected from at 4-24% of the stations and at these stations the number of individuals studied varied from few to many.

Lack of numbers of individuals of a host or stations available for examination does not explain fully the few epiphytes found thereon. Nor does the wide distribution nor the abundance of individuals of certain hosts showing the most varied epiphytic flora account for the presence of that flora. *Thuja occidentalis,* although examined at only 20% of the stations, supported 44 species of epiphytes, while *Pinus resinosa* and *Rhus vernix* also examined at the same number of stations yielded only five and nine species of epiphytes, respectively. *Betula lutea* and *Prunus serotina* both examined at 88% of the stations yielded 61 and 31 species of epiphytes.

The epiphytes observed have not shown a marked selectivity for host species, except, perhaps, in the case of certain lichens found particularly on conifers, usually in the mountains where the conifers were dominant. It seems evident, therefore, that the epiphytes appear on any species of host that by reason of its environment and physical features can provide the habitat within the limits of which they can survive or succeed.

Young trees rarely showed a well developed epiphytic flora, merely a little moss at the base with perhaps some crustose lichens scattered sparingly on the trunk. Certain older trees with trunks 1½ to 2 feet in diameter, usually in open places, might be literally covered with mosses, liverworts and lichens from stump to crown. The age of the tree, then, seems to be related to its epiphytic flora, particularly if it is not in a dense, shaded stand, but the age factor is indirect and operates primarily as it is reflected in the condition of the bark causing it to become more rough or fissured.

Actually the physical properties of the bark of the host species appear to be most important with respect to the presence of a rich epiphytic flora, and these especially as related to the production of a less xeric substratum for epiphytes.

Examination of the bark of those host species shown to yield most epiphytes in this study indicates that they all sooner or later have rough, somewhat fissured bark capable of absorbing or retaining much moisture. Likewise of the hosts yielding but few epiphytes some produce a relatively smooth bark which is incapable of absorbing and holding very much water. The small number of epiphytes found on others like *Pinus resinosa* and *Rhododendron maximum* may be due to the peeling or flaking of their bark.

DISTRIBUTION OF EPIPHYTES BY ZONES ON TREES

Of the 37 species of lichens observed as epiphytes 30 were observed on the trunks of trees; of these, three, *Cladonia pyxidata, Mycoblastus sanguinarius* var. *alpinus,* and *Peltigera canina,* were also found on stumps more commonly than on the trunks. Three species were observed only on stumps, *Leptogium tremelloides, Sticta pulmonaria,* and *Cladonia rangiferina.* While these species were rare as epiphytes, they were common at some stations on soil, dead stumps and decaying logs. The following fifteen species on trunks were also found growing on the crown or crown base of the host: *Alectoria chalybeiformis,* A. jubata,* Cetraria aurescens,* Evernia furfurcea,* E. prunastri,* Parmelia caperata, P. cetrata,* P. pertusa, P. physodes,* P. rudecta, Physcia astroidea, P. endochrysea, P. stellaris, Pyrenula nitida* and *Usnea barba.** (* = species most common on the crown.)

Two species, *Cetraria ciliaris* and *C. juniperina,* were limited chiefly to the crown.

Of the three species of algae observed as epiphytes all occurred on stumps, but *Protococcus viridis* and *Trentepohlia aurea* were more common on trunks. *Aphanothece* sp. was found only on moist stumps usually among mosses.

Of the 25 species of liverworts observed as epiphytes, 19 were found on

---

* Species most common on the crown.

trunks of trees. Only four species of these, *Frullanai eboracensis*, *Lophocolea heterophylla*, *Porella platyphylloidea* and *Ptilidium pulcherrimum*, were also observed sparingly in the crown. Fourteen of the species found on the trunk were also observed on the stumps of trees. Six species were found as epiphytes only on the stumps, *Bazzania trilobata*, *Calpogeia Neesiana*, *Chiloscyphus polyanthus*, *Porella platyphylla*, *Riccardia pinguis* and *Trichocolea tomentella*, but not elsewhere. With the exception of *Bazzania* these species were found as epiphytes in only a limited number of stations and on only one host, but they were often seen in abundance on wet humus or decaying logs.

Of the 43 mosses observed as epiphytes 30 were common on stumps and trunks. Two species, *Orthotrichum strangulatum* and *Brachythecium oxycladon*, were found on the crown. Five species, *Leucodon sciuroides*, *Orthotrichum strangulatum*, *Thuidium scitum*, *Ulota Ludwigii* and *U. ulophylla*, not observed on stumps, were found on trunks. The following eight mosses were not found above the stump: *Climacium americanum*, *Dicranum fulvum*, *Drepanocladus uncinatus*, *Fissidens adiantoides*, *Leptodictyum riparium*, *Pterigynandrum filiforme*, *Thelia asprella* and *T. hirtella*.

The three ferns, *Thelypteris marginalis*, *T. spinulosa* and *Polypodium virginianum*, were found only on stumps of a few hosts.

The zones are indicative of the variety of habitats possible on a host and represent some of the possible microclimates to be found thereon. The stump is usually the most mesic part of the host because it is so low that near it there is less movement of air and this results in a reduction in evaporation there. Its proximity to the soil often places it near a potential water reservoir. The splash of water during rains may add water, humus and some inorganic material to the stump, and in lowland regions at flood time, it may receive a deposit of silt. The presence of other plants near the stump may bring about a more humid atmosphere in which evaporation about the stump is reduced.

The trunk may represent a relatively more xeric habitat since it is normally farther above soil and subject to more of the desiccating action of air currents and to insolation which is intimately interrelated with temperature and the evaporating power of the air. Variations may be expected, however, depending on the slope of the trunk, the density of the stand in which the tree occurs and its bark type.

The crown base in deciduous trees in leaf may present a less xeric habitat than it does when the leaves have fallen and it is exposed and less protected from winds and sun. Flowage lines may contribute to its mesic nature as well by directing rain water into crotches in the crown base. With reference to the crown base, the crown is likely to be more xeric. This is also true for coniferous trees in the crowns of which conditions, though more xeric, would tend to be more uniform throughout the year. Presence of epiphytes, especially mosses, on any part of the tree may have a tendency to promote more mesic conditions in that area by reason of the actual water-holding or absorbent character of the plant mass.

The distribution of some epiphytes in New York is general, that of others

is restricted. The operation of the several factors affecting these distributions is dependent on the one hand on their magnitude and on the other hand on their combination with other factors. Light, temperature, movement of air, available water and soil types vary in their magnitude depending respectively upon the competition of trees or the density of a forest stand, altitude, exposure to winds, rainfall and geological origin of the substratum. Each of these factors may and often does modify the action of the other factors.

Different combinations of these variable factors are responsible for a number of micro-climates in which the action of any one factor may be highly dependent upon the magnitude of any of the other factors operative in a particular environment. The operation of this composite of factors upon the epiphytes produces an evaporational tension or stress resulting from the action of the evaporating power of the air, which is affected by any or all of the above mentioned factors, and in addition by the host species upon which the epiphytes grow. Other factors being equal, the evaporational tension may be highly dependent upon the moisture-absorbing capacity, both rate and volume, and the moisture-retaining capacity of the bark of the host tree. As these vary, in different hosts, both with the structure of the bark and its position with reference to the physical factors mentioned, to that extent distribution of epiphytes may vary with the kind of host. However, it must be recognized that the amount and nature of the bark of many species of trees changes with their age, size, shape and exposures so that a single tree may present several micro-climates or conditions of evaporational stress making available a wider range of distribution or a larger variety of epiphytic types of limited distribution on it than might be found among the several species of hosts comprising a whole forest of trees of younger age, uniform age, or under uniform environmental conditions, e.g. The smoth bark of a young *Populus tremuloides* or *Betula lutea* may support a growth of *Graphis scripta* or *Frullania eboracensis,* species common on hosts with a smooth bark, but with age these trees may develop a very rough or ridged bark, first at their base and later farther up on the trunk which is then invaded by mosses and liverworts which are commonly found on trees which early develop a rough or ridged bark. What may be the ultimate or final association of epiphytes on one host may also occur on another host but representing only one stage in a series of successions that may culminate in a different climax association.

The invasion, ecesis and succession of epiphytic species on a particular host, dependent as these are upon the complex of factors that contribute to evaporational tension and upon the contributions that bark characteristics make thereto, may in the final analysis also be dependent upon the nature of the epiphyte. The morphological modifications for the absorption and storage of water as well as the nature of the protective covering of the thallus and the conservatism in the type of plant body which does not expose an excessive surface to the desiccating atmosphere may determine the success of one species as an epiphyte where others fail.

From this discussion of the interaction of factors, it is not surprising that the total number of true or especially obligate epiphytes observed in New

York state is relatively small, that most of them appear generally distributed and that a few appear limited in their distribution. It becomes evident that the distributions as observed cannot be explained by the operation of a single factor but by a consideration of the interaction of several factors.

REFERENCES

EVANS, A. W. 1940—List of Hepaticae Found in the United States, Canada and Arctic America. Bryologist 43:133-138.

——— AND G. E. NICHOLS 1908—The Bryophytes of Connecticut. Conn. Geol. and Nat. Hist. Survey Bull. 11.

FINK, B. 1935—The Lichen Flora of the United States. 426 pp. Univ. Mich. Press.

FRYE, T. C., AND LOIS CLARK 1937-1946—Hepaticae of North America. Univ. Wash. Publ. Biol. 6:(I-IV)1-733.

GOEBEL, K. 1893—Die Epiphyten. In, Pflanzenbiologische Schilderungen Bd. II.

GROUT, A. J. 1924—Mosses with a Hand Lens. The Author, New Brighton, S. I., N. Y.

———1928-1940—Moss Flora of North America north of Mexico. (I:1-264) 1936-1939, (II:1-284) 1933-1940, (III:1-277) 1928-1934.

———1940—List of Mosses of North America north of Mexico. Bryologist 43: 117-131.

KERNER, A., AND F. W. OLIVER 1902—The Natural History of Plants I.

OCHSNER, F. 1928—Studien ueber die Epiphyten-Vegetation der Schweiz. Jahrb. der St. Gallischen Naturwiss. Gesellsch. 63:1-108.

SCHIMPER, A. F. W. 1903—Plant Geography (English edition).

STEERE, W. C. 1940—Liverworts of Southern Michigan. Cranbrook Inst. of Sci. Bull. 17. 1-97.

Appendix

The 111 species of plants observed growing as epiphytes are arranged in the following groups by families:

1. LICHENES—Lichens

(Arranged according to Fink, 1935)

Pyrenulaceae	Pyrenula nitida
Arthroniaceae	Arthrothelium spectabile
Graphidaceae	Graphis scripta
Collemaceae	Leptogium tremelloides
Stictaceae	Sticta pulmonaria
Peltigeraceae	Peltigera canina
Lecideaceae	Lecidea vernalis; Mycobluastus sanguinarius var. alpinus
Cladoniaceae	Cladonia pyxidata; C. rangiferina
Pertusariaceae	Pertusaria multipuncta
Lecanoraceae	Lecanora pallida; L. subfusca
Parmeliaceae	Parmelia caperata; P. cetrata; P. olivacea, P. perforata, P. perlata; P. pertusa; P. physodes, P. rudecta, Cetraria aurescens, C. ciliaris, C. juniperina.
Usneaceae	Evernia furfuracea, E. prunastri, Alectoria chalybeiformis, A. jubata, Ramalina calicaris, R. pollinaria, Usnea barbata
Buelliaceae	Buellia parasema
Physciaceae	Physcia astroidea, P. endochrysea, P. stellaris, P. tribacia, Anaptychia aquila var. detonsa

2. ALGAE

Chroococcaceae	Aphanothece sp.
Protococcaceae	Protococcus viridis
Trentepohliaceae	Trentepohlia aurea

3. HEPATICAE—Liverworts
(Arranged according to Evans, 1940)

Ptilidiaceae	Ptilidium pulcherrimum, Trichocolea tomentella
Lepidoziaceae	Bazzania trilobata, Lepidozia reptans
Calypogeiaceae	Calypogeia Neesiana
Cephaloziaceae	Cephalozia media, Nowellia curvifolia
Harpanthaceae	Lophocolea heterophylla, L. minor, Chiloscyphus polyanthus
Jungermanniaceae	Lophozia ventricosa, Orthocaulis attenuatus (*Lophozia attenuata*), Jamesoniella autumnalis
Plagiochilaceae	Plagiochila asplenioides
Scapaniaceae	Scapania nemorosa
Porellaceae	Porella pinnata, P. platyphylla, P. platyphylloidea
Radulaceae	Radula complanata
Frullaniaceae	Frullania Asagrayana, F. eboracensis
Lejeuneaceae	Lejeunea cavifolia, Cololejeunea Biddlecomiae
Riccardiaceae	Riccardia latifrons, R. pinguis

4. MUSCI—Mosses
(Arranged according to Grout, 1940)

Fissidentaceae	Fissidens adiantoides
Dicranaceae	Dicranum flagellare, D. fulvum, D. fuscescens, D. montanum, Paraleucobryum longifolium (*Dicranum longifolium*)
Orthotrichaceae	Orthotrichum strangulatum, Ulota crispa (*Ulota ulophylla*), U. Ludwigii
Bryaceae	Rhodobryum roseum
Hypnaceae	Amblystegium serpens, A. varium, Brachythecium oxycladon, B. Starkei, Brotherella recurvans, Calliergonella Schreberi (*Hypnum Schreberi*), Campylium chrysophyllum, C. hispidulum, Climacium americanum, C. Kindbergii, Drepanocladus uncinatus, Heterophyllium Haldanianum (*Hypnum Haldanianum*), Hypnum crista-castrensis, H. cupressiforme, H. imponens, H. pallescens, H. reptile, Leptodictyum riparium, Plagiothecium denticulatum, P. striatellum, Platygyrium repens, Pylaisia intricata (*Pylaisia velutina*), P. Selwynii
Leskeaceae	Anomodon attenuatus, A. rostratus, A. Rugelii, Pterigynandrum filiforme, Thelia asprella, T. hirtella, Thuidium delicatulum, T. scitum
Neckeraceae	Neckera pennata
Leucodontaceae	Leucodon sciuroides

5. PTERIDOPHYTA—Ferns

Polypodiaceae	Polypodium virginianum, Thelypteris marginalis, T. spinulosa.

Notes on Eriogonum

Geo. J. Goodman
Department of Plant Sciences, University of Oklahoma, Norman

Three species of *Eriogonum* have been referred to both that genus and to *Oxytheca* for more than half a century. In studying the genus *Oxytheca*, it became desirable to look critically at these species. All three species are considered to be Eriogonums for reasons that will be pointed out later. Distribution data are presented as completely as practicable, and one new variety is described. The number of collections examined is given, as well as the average flowering time. A specimen is cited for each county from which a collection was seen. At the end of the paper there is a complete list of specimens examined.

The curators of the following herbaria are cordially thanked for their generosity in lending specimens: California Academy of Sciences, University of California (including the Clokey Herbarium), Gray, Missouri Botanical Garden, New York Botanical Garden, Academy of Natural Sciences of Philadelphia, Pomona College, and United States National Herbarium.

ERIOGONUM SPERGULINUM Gray, Proc. Am. Acad. 7:389. 1868.
Oxytheca spergulina (Gray) Greene, Fl. Francis. 153. 1891.
O. Reddingiona Jones, Bull. Torr. Bot. Club 9:32. 1882.

One hundred fifty sheets, representing 105 collections have been examined.

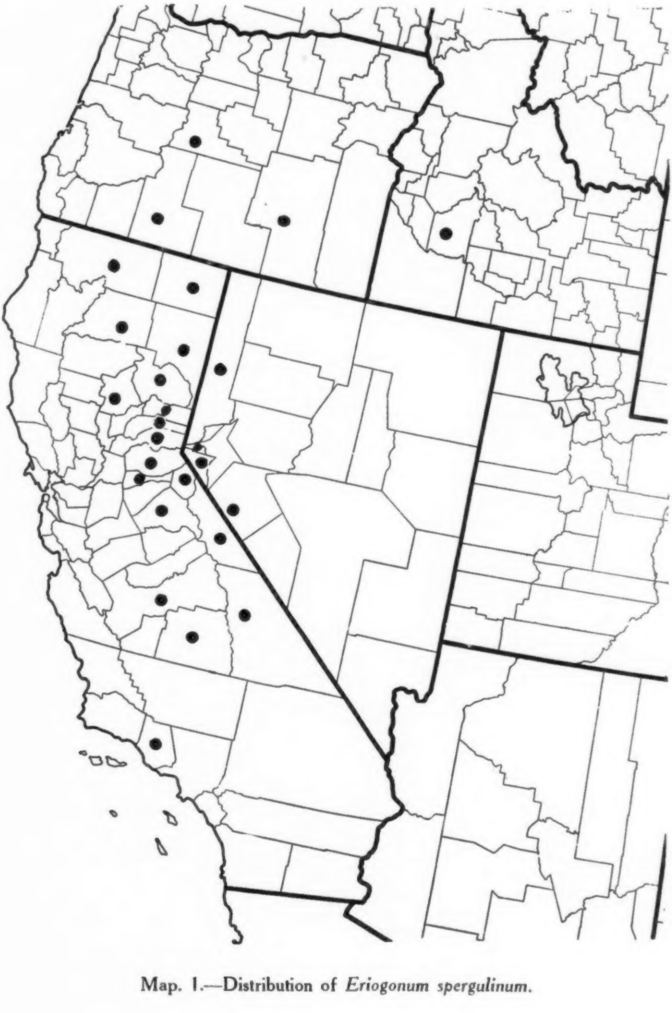
Type.—"Dry sandy soil, banks of the Big Creek below the Mariposa Big Tree Grove, Bolander," (5003). (Gray Herb.).

Range.—East of the divide of the Coast Ranges from central Oregon south in California to Fresno, Tulare, and Inyo counties and Ventura county, in adjacent parts of Nevada, and Idaho.

Flowering time.—June to October, but mostly July.

IDAHO: Long Valley, 4100 ft., July 5, 1895, *L. F. Henderson 3120;* ELMORE CO., sunny slopes, Trinity Lake region, 8000 ft., Aug. 30, 1910, *J. F. Macbride 709.* OREGON: DESCHUTE CO., west shore of Davis Lake, about 4500 ft., June 27, 1939, *C. L. Hitchcock and J. S. Martin 4956;* HARNEY CO., open sagebrush slopes by road to Fish Lake, Steens Mts., 7000 ft., July 16, 1935, *J. Wm. Thompson 12118;* KLAMATH CO., in pumice sand near Beaver River, 1650 m., Aug. 3, 1894, *J. B. Leiberg 616.* NEVADA: DOUGLAS CO., Spooner, 2155 m., June 23, 1902, *C. F. Baker 1136;* MINERAL CO., dry canyon roadside head of North Cat Canyon, west side Mt. Grant, 9000 ft., July 3, 1940, fls. pink, *P. Train 4209;* ORMSBY CO.: dry creek bottom slopes, granite soil near Marlette Lake, July 8, 1939, *P. Train 3220;* WASHOE CO., Galena Creek, 8000 ft., Aug. 1, 1906, *P. B. Kennedy 1244.* CALIFORNIA: ALPINE CO., sandy soil in light shade with Ceanothus, Holodiscus, and Acer in Abies—Juniperus association, above Deadman Creek, 8000 ft., Aug. 6, 1938, *L. Constance 2406;* AMADOR CO., Bear River, July 30, 1896, *Geo. Hansen 1920;* BUTTE CO., ridge between Jones and N. Willow Creeks, 1700 m., July 11, 1931, *E. B. Copland 633;* ELDORADO CO., open places in forest, Echo Camp, 7000 ft., Aug. 6, 1915, *A. A. Heller 12187;* FRESNO CO., Pine Ridge, 5300 ft., June 15-25, 1900, *H. M. Hall and H. P. Chandler 190;* INYO CO., Pine City near Mammoth, July, 1915, *K. Brandegee;* LASSEN CO., Harvey Valley, July 6, 1934, *Howell 12446;* MODOC CO., near Lost Lake, Warner Mts.,

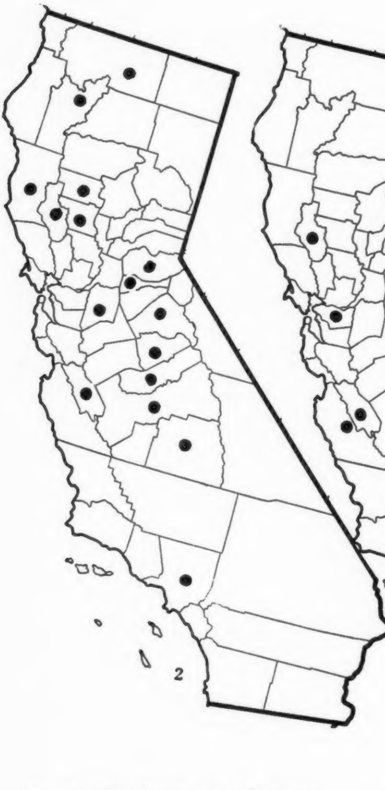
about 8000 ft., June 14, 1934, *J. T. Howell 12123;* MONO CO., open rock slopes, Convict Lake, 7583 ft., July 15, 1935, *L. S. Rose 35345;* NEVADA CO., lower end of Donner Lake, July 10, 1903, *A. A. Heller 6905;* PLACER CO., sandy flats in open forest of Pinus ponderosa and Abies concolor, Chambers Lodge, Lake Tahoe, about 1900 m., July 8, 1941, *L. S. Rose 41290;* PLUMAS CO., in woods, on road from Chilcott, June, 1927, *A. Eastwood 14888;* SHASTA CO., Lassen's Peak, 6000 ft., July 8,

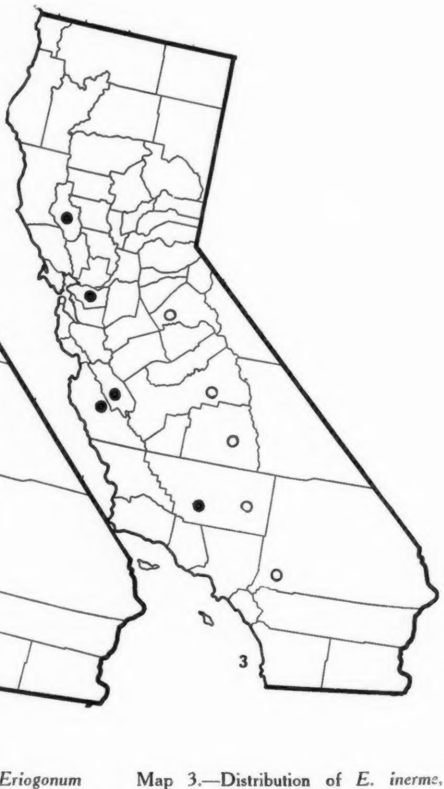


Map. 1.—Distribution of *Eriogonum spergulinum*.

1897, *M. E. Jones;* SIERRA CO., rocky slopes, Gold Lake, 6400 ft., July 4, 1934, *L. S. Rose 34317;* SISKIYOU CO., Ash Creek, Mt. Shasta, July 31, 1899, *M. S. Baker;* TULARE CO., near Mineral King, 2750 m., Aug. 3, 1891, *F. V. Colville and F. Funston 1453;* TUOLUMNE CO., common on granite soil flats near streams, Tuolumne Meadows, July 4, 1928, *H. L. Mason 4871;* VENTURA CO., common on gentle slopes, Mt. Pinos, 7200-8000 ft., June 11, 1923, *P. A. Munz 7042;* Yosemite National Park, dry gravel slope, Glacier Point, 7100 ft., July 5, 1925, *D. D. Keck 191.*

This species is notable for its remarkable uniformity. Only one collection (Coville and Funston 1622, from Whitney Meadows, Tulare Co., California, 1891) with unusually strigose perianths might attract attention. This material was from an area where the usual form is common.





Map 2.—Distribution of *Eriogonum hirtiflorum.* The record for San Joaquin County is Bot. Calif. 2.480.

Map 3.—Distribution of *E. inerme,* var. *hispidulum* . . . °, var *typicum* . . . •

ERIOGONUM HIRTIFLORUM Gray ex Wats., Proc. Am. Acad. 12:259. 1877.
Oxytheca hirtiflora (Gray) Greene, Fl. Francis. 153. 1891.

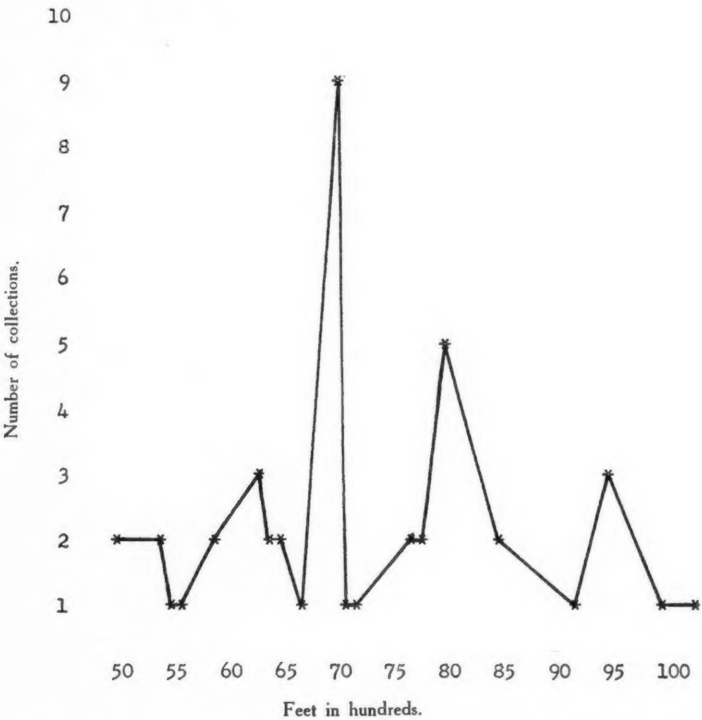
Forty-three collections of this species have been examined.

Type.—"Collected by Dr. Gray, 1872, probably in the mountains of California." (Gray Herb.).

Range.—Northern California south to San Benito, Fresno, and Tulare counties, and Los Angeles county.

Flowering time.—May to October, but mostly June and July.

CALIFORNIA: AMADOR CO., Ione, May, 1889, *C. C. Parry;* COLUSA CO., under Adenostoma, east slope Black Butte, June, 1884, *V. Rattan 65;* ELDORADO CO., Sweetwater Creek, July, 1883, *K. Curran;* FRESNO CO., Meadow Lake, 1931, *J. McDonald;* GLENN CO., between Mud Flat and Bennett Spring on the Newville-Covelo road, July 8, 1914, *A. A. Heller 11352;* LAKE CO., in chaparral, with Nemacladus, in hills about Scotts Valley, 6 mi. n. w. of Lakeport, May 30, 1902, *J. P. Tracy 1650;* LOS ANGELES CO., grassy clearing in chaparral . . . on N. Fork Tujunga Creek, San Gabriel Mts., June 12, 1932, *J. A. Ewan 7366;* MADERA CO., Ahwahnee, 2600 ft., Oct. 25,



Graph 1.—Elevations of 44 collection stations of *Eriogonum spergulinum* as based on information on labels.

1930, *M. halperin* (an unusually glabrous and glandless specimen); MARIPOSA CO., clay soil and gravel in partial shade, 3 miles eastward from Bootjack, Oct. 11, 1931, *J. T. Howell 8141* (a form with proliferated involucres); MENDOCINO CO., Red Mt., June 23, 1901, *A. Eastwood;* SAN BENITO CO., The Pinnacles, May 19, 1937, *J. T. Howell 12947;* SISKIYOU CO., Edgewood, July, 1877, *T. S. Brandegee;* TRINITY CO., hills west of Weaverville, July 3, 1937, *C. H. True 761;* TULARE CO., on grade below switch backs, above Camp Nelson, Sequoia Natl. Forest, 5540 ft., July 26-28, 1941, *R. Bacigalupi, I. L. Wiggins and R. S. Ferris 2648;* TUOLUMNE CO., volcanic slopes, 2.5 miles above Long Barn, July 23, 1934, *I. L. Wiggins 6936;* county not known, the type.

The characteristic branching of this little annual results in an elm tree-shaped plant. This is brought about by the lower branch of each fork acting as the main axis, the upper branch dividing a few more times into short flowerin branches.

There is a sharp difference in the length of the uncinate hairs on the calices, those at the base being much shorter. The mature achene is well exserted, and this portion is nearly parallel sided. These characters are helpful in separating this species from the next when the material is fragmentary.

ERIOGONUM INERME (Wats.) Jeps., Fl. Calif. 1:406. 1914.

Oxytheca inermis Wats., Proc. Am. Acad. 12:273. 1877.

Eriogonum vagans Wats. l. c. 20:370. 1885, (substitute name for *O. inermis*).

Eriogonum inerme var. **typicum** Goodman, n. name.

Involucres glabrate.

Nine collections have been examined.

Type.—"California, probably on Mt. Diablo: collected only by Miss M. J. Bancroft," 1876. (Gray Herb.).

Range.—Coast ranges of central California.

Flowering time.—June-July.

CALIFORNIA: CONTRA COSTA CO., the type; KERN CO., Water Canyon, Tehachapi Mts., 7000 ft., June 26, 1908, *L. Abrams and E. McGregor 454;* LAKE CO., Pinnacle Rock, Bartlett Mt., June 20, 1945, *J. T. Howell 21120;* MONTEREY CO., Priest Valley, *A. Eastwood;* SAN BENITO CO., Hernandez, *A. Eastwood.*

Eriogonum inerme var. **hispidulum** Goodman, n. var.

Involucris hispidulis.

Twenty-one collections have been examined.

Type.—San Bernardino Mts., California, July 1, 1882, W. G. Wright 258. (Herb M. B. G.).

Range.—West of the coast ranges; central to southern California.

Flowering time.—May-Aug.

CALIFORNIA: FRESNO CO., Hume Lake, Aug. 11, 1940, *J. T. Howell 16152;* KERN CO., near Havilah, 975 m., June 24, 1891, *F. V. Coville and F. Funston 1080;* SAN BERNARDINO CO., the type; TULARE CO., sandy roadcut, Kern River Valley above Kernville, 3800 ft., June 7, 1941, *H. D. Ripley and R. C. Barneby 3779;* TUOLUMNE CO., between Long Barn and Cold Spring, 4500 ft., July 20, 1911, *L. Abrams 4733.*

LIST OF COLLECTIONS EXAMINED

Eriogonum spergulinum

Abrams, L., 4696 (NY), 9663 (NY, Pom), 12716 (NY, Pom).
Abrams, L. & McGregor, E. A., 249 (NY).
Archer, W. A., 5489 (NY).
Austin, Mrs. R. M., s.n., 1896 (NY, US).
Baker, M. S., s.n. (Pom), s.n., 1899 (Pom), 1136 (NY, Pom).
Baker, M. S. & Nutting, F., s.n., 1894 (US).
Bacigalupi, R., 1703 (Pom).
Bacigalupi, R. & Ferriss, R. S. & Wiggins, I. L., 2542 (NY).
Bebb, M., 283 (Bebb), 388 (Bebb).
Belshaw, C. M., 2640 (NY, Pom).
Bolander, H. N., 5003 (ISC, NY).
Brandegee, s.n., 1889 (NY).
Brandegee, K., s.n., 1905 (Pom), s.n., 1915 (NY).
Brewer, W. H., 1953 (NY, US).
Bridges, 277(a) (NY).
Clausen, J., 1611 (M, NY, Pom).
Clemens, Mrs. J., s.n., 1910 (Pom).
Constance, L., 2406 (NY).
Copeland, E. B., 633 (NY, Pom).
Copeland, H. F., 1537 (Pom).
Coville, F. V. & Funston, F., 1453 (US), 1622 (NY, US).
Craig, T. & F., 3630 (Pom).
Culbertson, 4443 (NY, Pom), 4570 (NY, Pom).
Davidson, A., 1701 (NY).
Dudley, W. R., 3180 (NY).
Eastwood, A., 185 (C-UC), 486 (US), 1752 (C-UC, US), 14888 (Pom).
Edwards, H., s.n. (NY), s.n., 1884 (NY).
Eggleston, W. W., 7387 (NY).
Elmer, A. D. E., 3979 (NY, Pom, US).
Evans, H. M., s.n. (Pom).
Ferris, R. A., 6794 (Pom).
Grant, A. L., 1128 (Pom).
Grant, G. B., s.n. (Pom).
Greene, E. L., 386 (ISC, NY).
Hall, H. M., & Chandler, H. P., 190 (NY, Pom).
Hansen, G., 304 (NY, US), 703 (NY, US), 1920 (NY), 1928 (NY, US).
Heller A. A., 6905 (ISC, NY, Ph, Pom, US), 12187 (NY), 12894 (NY), 16272 (NY).
Heller, A. A. & Kennedy, P. B., 8801 (ISC, NY, Ph, Pom, US).
Henderson, L. F., 3120 (US).
Hitchcock, C. L. & Martin, J. S., 4956 (NY, Pom).
Holman, R., s.n., 1934 (NY, Pom).
Howell, J. T., 12123 (NY), 12446 (NY, Pom), 14504 (NY).
Jones, M. E., s.n., 1882 (NY), s.n., June 21, 1897 (NY, Pom), s.n., July 8, 1897 (Pom), s.n., 1903 (Pom), 2408 (Pom, US), 28856 (Pom).
Keck, D., 191 (Pom), 1560 (Pom).
Kellogg, A. & Harford, W. G. W., 16 (US).
Kennedy, P. B., 1244 (NY).
Leiberg, J. B., 616 (NY, Pom, US), 5133 (US).
Lemmon, J. G., s.n. (NY).
Mason, H. L., 4871 (M, NY, Pom).
McBride, J. F., 709 (NY).
McGregor, E. A., 48 (NY), 189 (NY).
Munz, P. A., 7042 (Pom), 7481 (NY, Pom), 14423 (Pom).
Palmer, E., 181 (NY), 196 (NY).
Peck, M. E., 9570 (NY), 16896 (NY).
Peirson, F. W., s.n., 1922 (Pom), s.n., 1927 (Pom), 6792 (Pom).
Rose, L. S., 34317 (NY, Pom), 35345 (NY, Pom), 35520 (NY), 40693 (Pom), 41290 (Bebb, NY).
Rowntree, Mrs. L., s.n., 1929 (Pom).
Sonne, C. F., s.n., 1884 (Pom).
Thompson, J. H., s.n., 1906 (US), 12118 (M, NY).
Train, P., 3220 (NY), 4209 (NY).
Wiggins, I. L., 8946 (NY), 9501 (NY).
Youngberg, F., 178 (Pom).

Eriogonum hirtiflorum

Bacigalupi, R. & Wiggins, I. L. & Ferriss, R. S., 2648 (CAS, G).
Baker, M. S., 10141 (CAS), 11074 (CAS).
Brandegee, K., s.n., (UC), s.n., 1905 (UC).
Brandegee, T. S., s.n., 1884 (UC), s.n., 1887 (UC), s.n., July 18 1892 (UC), s.n., July 24, 1892 (UC), s.n., 1894 (UC).
Congdon, J. W., s.n., 1883 (UC), s.n., 1895 (NY).

Curran, K., s.n., June, 1883 (G, UC), s.n., July 1883 (G), s.n., 1884 (G, UC).
Eastwood, A., s.n., 1893 (UC), s.n., 1901 (NY, UC), s.n., 1907 (G), 134 (CAS).
Ewan, J. A., 7366 (Bebb, CAS).
Ewan, J. A. & Dunn, A. N., 7830 (CAS).
Gray, A., s.n., 1872 (G).
Halperin, M., s.n., 1930 (CAS).
Heller, A. A., 11552 (CAS, G, M, NY UC, US), 12759a (CAS, G, NY).
Howell, J. T., 8141 (CAS), 12947 (CAS, G), 18910 (CAS), 20993 (CAS), 21200 (CAS).
McDonald, J., s.n., 1931 (CAS).
Parry, C. C., s.n., 1881 (ISC, NY), s.n., 1889 (ISC, NY).
Peirson, F. & M., s.n., 1906 (G).
Rattan, V., s.n., 1884 (UC), 65 (G).
Rose, L. S., 37288 (C-UC).
Scholthess, P., s.n., 1931 (UC).
Tracy, J. P., 1650 (UC).
True, G. H., 761 (CAS).
Wiggins, I. L., 6936 (G).

Eriogonum inerme var. *typicum*

Abrams, L. & McGregor, E. A., 454 (G, NY).
Bancroft, M. J., s.n., 1876 (G).
Brandegee, K., s.n., 1884 (CAS).
Curran, M. K., s.n., June, 1884 (NY), s.n., July, 1884 (UC).
Eastwood, A., s.n., (UC).
Ewan, J. A., 7788 (Bebb, UC).
Howell, J. T., 21120 (CAS).

Eriogonum inerme var. *hispidulum*

Abrams, L., 4733 (NY).
Bacigalupi, R. & Ferris, R. S., 2465 (G).
Brandegee, K., s.n., May 15, 1892 (UC), s.n., 1911 (UC). The 1892 collection was doubtless made by T. S. Brandegee, as shown by the known distribution of the variety and by the information in Joseph Ewan's most valuable paper, A Bibliogeographical Guide to the Brandegee Botanical Collections (Amer. Midl. Nat. 27:772-789. 1942).
Brandegee, T. S., s.n., 1892 (UC).
Coville, F. V. & Funston, F. 1080 (US).
Curran, M. K., s.n. (G).
Dearing, H. & M., 4392 (UC).
Eastwood, A., s.n., 1893 (UC).
Eastwood, A. & Howell, J. T., 7469 (CAS).
Howell, J. T., 16152 (CAS).
Palmer, E., 35 (G, NY).
Parish, S. B., s.n., 1884 (NY), 1580 (G, NY, US).
Parish, S. B. & W. F., s.n., 1884 (ISC, UC).
Purpus, C. A., s.n., 1898 (UC).
Ripley, H. D. & Barneby, R. C., 3779 (CAS).
Wright, W. G., s.n., 1881 (M), s.n., 1882 (ISC, NY), 258 (G, ISC, M, NY).

The Lilacs of Mackinac Island

Carl D. La Rue
Department of Botany, University of Michigan, Ann Arbor

The lilacs of Mackinac Island, soon to be emphasized in a moving picture taken on that historic island, have been widely known for their large size and great age, but it is doubtful whether many persons have realized how unusual they really are. I had observed their unusual size several times in the last ten years and wondered about their age and growth rate. On June 23, 1947, I had an opportunity to satisfy my curiosity, at least in part, by measuring a number of them. I was surprised to find that they were much larger than I had supposed and that some of them had diameters at the butt which would be significant to a lumberman.

According to popular report the oldest lilacs were planted by the Jesuits at an early date. The story is plausible, though I have not attempted confirmation.

By far the greater number of the old lilacs belong to the species, *Syringa vulgaris,* the common lilac, but white lilacs, *Syringa vulgaris* variety *alba,* are common. As elsewhere, the white lilacs are taller than the purple ones and have longer trunks, which, however, do not compare in girth with those of the purple type.

Lilacs, under usual conditions tend to be shrubs with many stems but they respond readily to training into tree forms. Those of Mackinac Island are nearly all reduced to a few stems, either by training or by survival, but one huge specimen had a vast number of stems, both ancient and recent. There are many of tree forms which appear to have been trained to a single stem. These are true trees, since they exceed by far, the dimensions usually ascribed to shrubs. On most of them, the trunks are very short so diameters could not be measured at the standard *breast height.* Instead, measurements were made as near the ground level as possible, but above the root crown in any case. The data secured are given in Table 1. Many more trees were seen which appeared to range from six to nine inches in diameter.

Many trunks are gnarled and covered with knotty excrescences and remind one of the trunks of ancient olive trees. These irregularities made accurate measurements impossible, but the percentage of error involved in the measurements given in Table 1 is not great. Some of the largest trunks are smooth, so it is evident that the large sizes presented are not due merely to knots.

In plants with multiple trunks, all appear to fuse at the root crown and if the diameters of the root crowns could be secured they would be impressive. For example in the specimen shown with five trunks, the five circumferences add up to 173¾ inches. Of course, if the trunks were fused, the total circum-

ference would be less than this, but it would be much greater than that found in any single trunk.

TABLE 1.—Diameters of Lilacs on Mackinac Island.

Type	Number of Trunks	Diameter in Inches	Remarks
Syringa vulgaris	3	11.1 9.9 10.1	
Syringa vulgaris	1	9.6	
Syringa vulgaris	1	14.0	
Syringa vulgaris	1	11.2	
Syringa vulgaris	1	9.6	
Syringa vulgaris	1	7.9	
Syringa vulgaris	5	14.1 11.8 8.8 10.6 9.7	
Syringa vulgaris	2	15.7 11.6	
Syringa vulgaris	1	16.0	
Syringa vulgaris	1	8.9	
Syringa vulgaris	1	19.2	branch at 5′ is 12.7″ in diameter
Syringa vulgaris	1	16.8	branches at 5′ are 9.8″ and 10.2″ in diameter
Syringa vulgaris	1	18.3	
Syringa vulgaris	1	15.1	
Syringa vulgaris	1	21.8	
Syringa vulgaris	2	12.7 11.9	
Syringa vulgaris	1	12.4	
Syringa vulgaris	1	23.6	
Syringa vulgaris	2	15.8 13.9	
Syringa vulgaris	1	20.3	
Syringa vulgaris var. *alba*	2	7.5 6.5	
Syringa vulgaris var. *alba*	1	7.2	
Syringa vulgaris var. *alba*	1	9.3	

The largest trees are found in the old part of the village on the lower levels and near the shore. The largest lie toward the east end of the village. The largest (Fig. 1) was found a little east of the Church of St. Ann, and the second largest one was across the street from that church. A fine specimen grows in front of the Early House where Alexis St. Martin received the wound which allowed him to become the subject of the famous experiments of Dr. Beaumont on the physiology of the stomach. This tree is 16.7 inches in diameter and splits into two branches at the five-foot level, one 9.9 and one 10.3 inches in circumference.

The five-trunked giant shown in the table is in front of the old Astor House (1818-1829). In the grounds of the building, along the sidewalk of the street, there is a row of ten plants, all nearly as large as this one.

Heights of the trees were not measured but many reached beyond the eaves of two-story houses. The tallest are estimated to be betwen 25 and 30 feet in height.

All of the trees examined were in remarkably fine condition. The leaves are smaller than those of young plants but both twigs and leaves fail to show the depauperate appearance of old lilacs farther south. No scale infestation was seen, and no signs of mildew, though it was probably too early in the season for this to be visible. Some plants had lost large trunks, (the five-trunked tree at Astor House had lost two nearly as large as the survivors), but no dead trunks or large dead branches, and remarkably few small ones were seen on this inspection.

The trees appear to grow rather slowly. Rings were counted in a branch 40 inches in circumference which had been sawed off cleanly. A core 2″ long was drilled with an increment borer in a dead trunk. The wood was exceedingly hard, and threatened to break the instrument if the boring were continued. From the ring counts obtained, the annual rings appeared to average 10 to the inch, which means the diameters increased an inch in five years. At this rate the oldest tree measured would be about 118 years old. The trees on

Fig. 1.—The largest lilac tree on Mackinac Island. It is almost two feet in diameter at the base.

the grounds of the old Astor House appear not to have been planted during the time that original structure existed (1818-1829), but probably were set out some fifty years later. The data are too scanty to be reliable but they indicate that the trees are not remarkably old, and do not date back to the earliest days of the settlement. Even so, they must be among the oldest, as they surely are among the largest lilacs in the United States. I know of no records of size in lilacs. Unfortunately, while much is known of the life span of species of trees, and many records exist of unusually large specimens, similar data have seldom been collected for shrubs.

In southern Michigan, and similar regions, the main trunks of lilacs do not live very long, although the roots may persist indefinitely. Although they are very tolerant of less satisfactory conditions, lilacs undoubtedly prefer a cool climate. The giants on Mackinac Island owe their stature to favorable growth conditions and a long period of undisturbed development.

Book Reviews

Scientists Starred 1903-1943 In American Men of Science, a Study of Collegiate and Doctoral Training, Birthplace, Distribution, Backgrounds, and Developmental Influences. By Stephen Sargent Visher. The Johns Hopkins Press, Baltimore, 1947. xxiii+556 pp., $4.50.

Professor J. McKeen Cattell inaugurated a system of starring presumed leaders in certain fields of science with the first edition of *American Men of Science* (1903). Although there have been numerous expressions of disapproval of the methods which he employed and against his refusal to admit border-line sciences and newly developed fields of science, he carried his plan with few changes in procedure through the seven editions prepared before his death in 1944.

For more than 25 years Doctor Visher has given an analysis of the selections in each edition of *American Men of Science*. Now he comes forth with a critical analysis of all the data. In the present volume he has ably reviewed the entire history of *starring*. Many of his conclusions and suggestions are presented in summary form (chapter 2) as extended series of graphs showing comparative standing of various institutions in training recognized leaders in the various fields of science. He has included not alone lists of names in the recognized sciences but he has likewise given collated information obtained through replies to a searching questionnaire addressed to the individuals who had been starred.

Among the particularly interesting materials there is a chapter (4) on the *Collegiate Training of the Starred Scientists* with a listing of alumni for each recognized science in each of the institutions of higher education and a summary of starred alumni for each college by years (or in some instances by longer periods). A similar analysis of *Doctoral Training* is presented in Chapter 5. Ready cross reference is available in another listing which names all starred doctors from each institution.

Many readers will find interest in the chapter (6) which discusses the education and background of recognized scientists who do not hold the doctorate and those who are not graduates of any college. Age at starring, age at death, month of birth, and birthplace are presented in chapters 7 and 8 along with numerous tabular analyses of the data.

Much of the discussion makes fascinating reading and many of the listings facilitate comparisons of institutions and contrasts between the varied fields of science but there are relatively few specific points which can be selected for special emphasis in a brief review. The amount of material encompassed is so great that it is not surprising to find a few minor errors and inconsistencies. The reviewer has made no complete critical check, but he encountered among the records of his immediate acquaintances one man who has been credited to the wrong university for his doctorate and one doctorate recorded in the wrong field. The latter is an instance of a chemist who later entered the field of physiology and, in the compilation, his field of activity has been confused with the field in which he took the doctorate.

Especially in recent years there has been a growing divergence of opinion regarding the practice of *starring* names in *American Men of Science*. Some administrators have maintained that they have used the inconspicuous symbols as a relatively safe criterion in selecting men to fill top positions or for special recognition. On the contrary, some persons have argued that the method of selection has been so faulty that the designations are meaningless and often unfairly discriminatory.

Such divergence of opinion is not unexpected in a democratic society where any system savoring of cast, hierarchy or special privilege is placed on the defensive. However, most of the persons who are familiar with the system of selecting leaders in their respective fields of science adopt neither of the two extreme points of view expressed above. Most individuals seem to admit that as in all elections errors in judgment are made occasionally which may result in some deserving persons being not starred while others are given recognition on the basis of personality, promise or institutional backing rather than on the soundness of their scholarly attainments.

In the first edition of *American Men of Science* a much greater percentage of the included names was starred than in any subsequent ediiton. Of the approximately 4000 names included in the first edition 1000 were starred but in the later editions a much smaller proportion of new men was given recognition. Dr. Visher records that in 1943 "fewer than one twenty-fifth of those who were not elderly were starred." In another place he states that only about one thirty-second of the names newly sketched in the 1943 edition were starred.

The author has dealt with facts as they exist but no one can read the collated material without being painfully aware of the unfairness of the editors of *American Men of Science* in their refusal to give recognition to any other than the twelve fields arbitrarily accepted in 1903. Science has expanded greatly in the 40 years since that list was approved. Many entirely new disciplines have been added and have gained widely accepted respectability and many of the most fertile fields for research have been in the borderline areas between the old standard scientific disciplines yet a geneticist working on molds receives his recognition as a zoologist.

The tables and graphs of Dr. Visher's book offer endless opportunities for comparisons. Each reader may with pride or chagrin compare the showing of his alma mater with that of old rivals in athletics or in science. He may compare the standing of his place of employment with other institutions and will often be able to rate rather objectively the status of his own science with other sciences in the same and in other institutions.—HARLEY J. VAN CLEAVE, University of Illinois, Urbana.

PRINCIPLES OF MICROPALAEONTOLOGY. By Martin F. Glaessner. (First published, September, 1945, by Melbourne University Press, Carlton, Victoria, Australia). John Wiley and Sons, Inc., N. Y., 1947. xvi+296 pp., 64 text figures, 14 plates, 7 tables (5 folded). $6.00.

With the progress of micropaleontology* during the past several decades both in research and practical application, there has developed a growing need for a general textbook on the subject. Dr. Glaessner's book is the first of this kind to present a general review of the field.

The work is divided into three parts and is presented under the following headings: Part I, *Objects and Methods of Micropalaeontology;* Part II, *Palaeontology of the Foraminifera;* and Part III, *Stratigraphic Micropalaeontology*. In Part I, there is a brief discussion of the various groups of microscopic animals exclusive of the Order Foraminifera. The classification includes families and for some of the minor groups considers genera. Methods of collecting and studying microfossils are taken up as a separate chapter.

Part II comprises the major portion of the book which is devoted to the life history, structure, classification, and palaeo-ecology of the foraminifera. The author presents a revised classification of this Order. Essentially the revision is the elimination and consolidation of several families with the erection of seven superfamilies Astrorhizidea, Lituolidea, Endothyridea, Miliolidea, Lagenidea, Buliminidea, and Rotaliidea based upon (p. 87):

"1. The non-septate forms are more primitive than the septate. 2. The higher, or septate, spirally coiled arenaceous foraminifera form a well-defined group. 3. The Fusulinidae are derived directly from Endothyridae. 4. The different lines of the porcellaneous foraminifera have a common origin in a coiled non-septate form. 5. The Polymorphinidae are derived from Lagenidae but there is no clear evidence concerning the origin of this family. 6. The Cassidulinidae and Ellipsoidinidae (Pleurostomellidae) are related to the Buliminidae which can be traced back to a trochospiral ancestral form. Most of the other smaller calcareous perforate foraminifera are clearly derived from rotaloid (trochospiral) ancestors. 7. Most of the larger calcareous per-

* This spelling prevails in America whereas the more classical spelling of micropalaeontology is characteristic of Eastern Hemisphere authors. It is interesting to note the former on the jacket of the book and the latter in the author's title.

forate foraminifera including *Siderolites, Orbitoides, Lepidocyclina, Miogypsina,* and probably the nummulites, developed from a number of different but closely inter-related small rotaloid (trochospiral) ancestors.

Correspondingly, five subfamilies have been elevated to the following families: Endothyridae, Spirillinidae, Discorbidae, Gümbelinidae, and Ceratobuliminidae. A synopsis of the revised classification along with a comparison to Cushman's classification can be found in the appendix.

The practical use of microfossils is given in Part III with a brief but meaty account of the stratigraphic sequence of microfaunas related to the various geological periods. Principles of correlation of the sedimentary rocks by the use of microfossils is outlined. The author concludes his book with a short review of the progress of micropaleontology utilized in petroleum exploration in Europe, Russia, Northern Africa, Southwestern Asia, India, Burma, East Indies, and Australia.

This well-written treatment of micropaleontology reflects the author's training experience and interest by the emphasis he has placed on the one group of microfossils, the foraminifera, and their importance in the Tertiary sequence of rocks throughout the world. The reviewer feels that the remaining groups of organisms in the entire field of micropaleontology have been treated disproportionately compared to the foraminifera. I believe the author realizes this deficiency when he states there is need for a handbook of micropaleontology prepared by a number of specialists for this rapidly expanding field. Students will find the six supplementary tables on the diagnostic characters of the superfamilies and genera of the foraminifera particularly helpful. In addition, the extensive annotated bibliography of thirty pages of worldwide references furnishes a good foundation for a review of the science. American micropaleontologists will welcome the perspective offered by this cosmopolitan treatment as a valuable contribution to the subject.—R. C. GUTSCHICK, University of Notre Dame, Notre Dame, Indiana.

THE FUNGI. By Frederick A. Wolf and Frederick T. Wolf. John Wiley & Sons, Inc., 1947. Vol. I — 438 pages, $6.00. Vol. II — 538 pages, $6.50.

The evident purpose of the authors of *The Fungi* was to provide a reference and text which would fill the need for a work presenting a balanced and comprehensive picture of these organisms. The shortcomings of any single text previously available were obvious. Thus the need for a book such as this one was indeed great.

It would be difficult to find any two informed persons who would agree as to just what phases of general mycology should be included in such a book and how much relative space allotted to each. Hence this reviewer is inclined to commend the general selection and weighting of topics, in spite of what appear to him personally as being omissions and non-essential inclusions. Volume I is largely devoted to taxonomy, morphology and related cytological considerations. The numerous illustrations are, for the most part, line drawings and are clear and well done. The lichens are arbitrarily omitted and the Fungi Imperfecti are given more consideration than is usually allotted to them. In addition to a separate chapter on the latter group, frequent reference is made in other chapters to the imperfect forms of the fungi under consideration. This feature should be of particular aid to students specializing in plant pathology. The volume also contains a brief chaper on the isolation and cultivation of fungi, which could have been included just as well in the second volume.

Volume II deals largely with the activities of fungi, together with chapters on marine fungi, fossil fungi and geographical distribution. In several chapters various phases of the biochemistry of fungi are considered, and one chapter each is devoted to genetics, concepts of plant pathology, and medical mycology. Ecological considerations receive special attention in chapters on associative effects among fungi, fungus-insect relationships, and effects of temperature, radiation and substrate reaction (pH). Literature citations at the end of each chapter of Volume II and at appropriate points in the taxonomic part of Volume I add to the value of the book as a reference work.

It is regrettable that a book which is as potentially useful as *The Fungi* should have such numerous faults. The text is very poor in many places from the standpoint of

pedagogy, although its primary use would seem to be that of a textbook. Technical terms are frequently not defined, and in many instances it appears that the authors presuppose a considerable mycological background on the part of the student. A glossary is not provided.

Regardless of one's views concerning the system used in the classification of fungi by orders in chapter 3 of Volume I, there are omissions which are simply errors and would tend to confuse the student attempting to follow it. Furthermore the authors depart from the classification just mentioned in dealing with specific groups of fungi in later chapters. The reader has every right to infer that the authors presented this summary by orders as the one which they subsequently intended to follow.

The illustrations and the text are poorly correlated. Since references to the illustrations are not included in the text, it would seem that the illustration should at least be placed adjacent to that part of the text with which it is concerned. The figure illustrating *Stereum frustulosum*, for example, is placed six pages from the text reference to its family. There are two illustrations of *Daedalia* with no text reference within fifty pages and with legends which give no indication of its systematic position. The lack of sequence of figures seems entirely unnecessary, such as in the example in the systematic portion of the book in which we find figures of *Stereum* and *Hydnum* sandwiched between two polypores. Legends in Volume II are occasionally misleading or inexcusably erroneous as in the case of the inclusion of *Amanita caesarea* and *Morchella esculenta* in a figure entiled *Some common poisonous fungi*. Such points are not minutiae of the sort that specialists in various phases of mycology might be expected to level at the text.

Despite numerous shortcomings these volumes should enjoy considerable use in their present form. They represent a valuable contribuiton from the standpoint of the amount of information contained in a small compass. It is to be hoped that a second edition will be speedily forthcoming to rectify the errors of the first. Apparently only one professional mycologist was asked to read the manuscript prior to publication, which seems rather strange in view of the breadth of material covered and which perhaps accounts for the fact that certain types of errors were not caught prior to publication.—J. A. JUMP, University of Notre Dame, Notre Dame, Indiana.

BACTERIAL CHEMISTRY AND PHYSIOLOGY. By John Roger Porter. John Wiley & Sons, Inc., New York. 1946. x+1073 pages. $12.00.

In his preface Porter states that the present book was an outgrowth of a course in bacterial physiology in which the material became too profuse to be covered adequately in two semesters. Perusal of the material of the book readily shows why, since, in addition to serving as a text in bacterial physiology, it includes so much information that it easily doubles as an excellent reference to large fields of biochemistry and cellular physiology. The author surveyed a vast amount of published material and has done an excellent job in reducing it to simpler statements presented in orderly fashion.

In the first chapter are given the physical-chemical principles necessary for an understanding of the general subject. The following nine chapters deal with growth and death of bacteria, effects of physical and chemical agents, chemical composition, enzymes and respiration, nutrition, metabolism, and fermentation. A general index and an index to organisms cited are included. Each chapter is followed by a rather extensive bibliography, increasing the value of the book as a reference.

In addition to bacteria much research on the fungi has been summarized. One attractive feature is the inclusion of a list of the known pigments of the bacteria and fungi as well as a brief discussion of the possible significance of these compounds.

The multiplicity of biochemical transformations found in bacteria and reported in *Bacterial Chemistry and Physiology* makes this an essential addition wherever bacteriology, biochemistry, or physiology is of interest.—NOE HIGINBOTHAM, Argonne National Laboratory, Chicago, Ill.